RAILWAY ENGINEERING

AND MAINTENANCE OF WAY.

BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK

Vol. V | *Chicago* | DECEMBER, 1909 | *New York* | No. 12

 SEE PAGE 8

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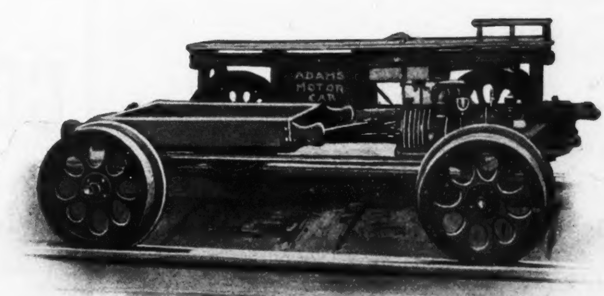
Simple,

Strong,

Steady,

Light,

Powerful



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RAILWAY ENGINEERING
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BRIDGES-BUILDINGS-CONTRACTING-SIGNALING-TRACK

Vol. 5 No. 12. December, 1909

Contents

Cableways at Gatun Locks, Panama

The building of the Panama Canal is now in its fourth and final stage. The first stage was the sanitation of the Canal Zone; the second, the rebuilding of the Panama Railroad so as to supply facilities for transporting the spoil from the excavations to the dumps; the third, the excavation of the canal; the fourth, and last stage, the building of the Gatun dam and locks, and the locks at Miraflores and San Miguel. On August 1st of this year, the excavation (182,000,000 cu. yds., of which 40,000,000 cu. yds. available had been done by the French) had advanced to a point where only 101,000,000 cu. yds. remained to be done, which, as officially stated by Col. Goethals, can be finished by August 1, 1911. The remaining excavation is proceeding at the rate of about 3,000,000 cu. yds. per month.

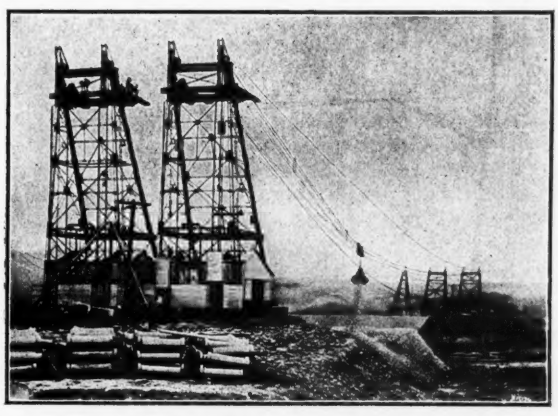


Fig. 1—Five Lidgerwood Cableways at Gatun Locks

Keeping pace with the speed of excavation are the construction operations in connection with the Gatun dam and locks. Perhaps the most important part of the mechanical equipment are the 13 Lidgerwood high speed cableways which were especially designed and installed for building the Gatun locks. Upon 5 of these, known as the unloader cableways, will fall the brunt of the work, and upon the ability of these 5 to handle the amount guaranteed, or more, must depend the question of whether the canal will be finished and in operation on January 1, 1915, or earlier. These cableways have exceeded their guaranteed capacity by such a large percentage that the engineers in charge of this section of the work are confident that it can be finished at a much earlier date. They are recognized unofficially by Col. Goethals as "that 1913 crowd."

The work of these 5 cableways is to handle the broken stone and sand which will be required for the walls and floors of the locks. There are 6 locks, each 1,000 feet long in the clear and 110 feet wide. They lie side by side in flights of three, making a total length of more than 3,000 feet. Together they provide a total lift of 85 feet, with some to spare for changes in the initial water level. In these locks there will be used 2,000,000 cu. yds. of broken stone, 1,000,000 cu. yds. of sand and 2,200,000 barrels of cement. The stone and sand arrive in barges on a branch of the old French Canal. The unloader cableway takes it out of the barges with grab buckets and delivers it 600 feet or more away in heaps in the storage yard. From here it is taken by the cars of an automatically operated electric railway to the mixers and from the mixers the concrete is taken in other electric cars to where the second set of 8 cableways can put it in place in the forms for the walls and floor. Four cableways arranged in pairs on two sets of towers handle the broken stone and a single cableway with independent towers unloads the sand from the barges and deposits it on a storage pile. Each cableway has a span of 800 feet. In the duplex cableways the cables are 18 feet apart. This corresponds with the distance apart of the transverse bulkheads

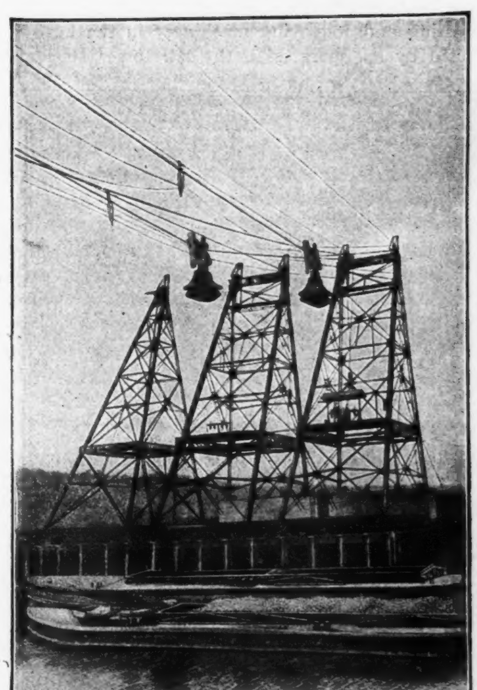


Fig. 2—Towers of Unloader Cableways

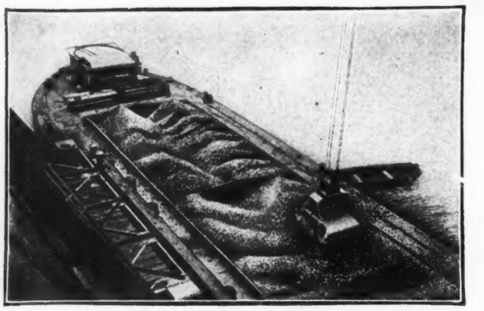


Fig. 3—Looking at Loaded Barge from Operator's Booth

in the barges. The cableways are all mounted on steel towers 85 feet high. The towers are mounted on trucks and travel on tracks, so that each cableway performs the function of a traveling crane. The unloader cableways travel the length of the storage yard. Those for building the locks travel more than 3,000 feet. They are all moved electrically, each pair in unison. From the carriage of each of the 5 unloaded cableways there is suspended an improved 70 cu. ft. iron-ore type of excavating bucket. Each bucket grabs an average load of 54 cu. ft. The load is hoisted 85 ft., conveyed about 600 ft., dumped on the storage pile, and the carriage and bucket returned. This round trip has been made in 1 minute and 8 seconds. The cableways were guaranteed to handle 50 cu. yds. an hour each. They have carried 90 cu. yds. in an hour, and the average operation up to date is 60 cu. yds. per hour. This ought to be materially increased with practice. The present record is declared to be double that of any cableway previously employed anywhere.

The high speed and consequent increase in the capacity of the cableways is due to the ease with which the operation of the cableways is controlled; the rope-lead that simultaneously raises and traverses the bucket; the high-speed shock-absorber with which the fall-rope carrier is equipped, and a new type of button-stop.

The hoisting and conveying machinery in the head tower is controlled by an operator in the tall tower stationed on

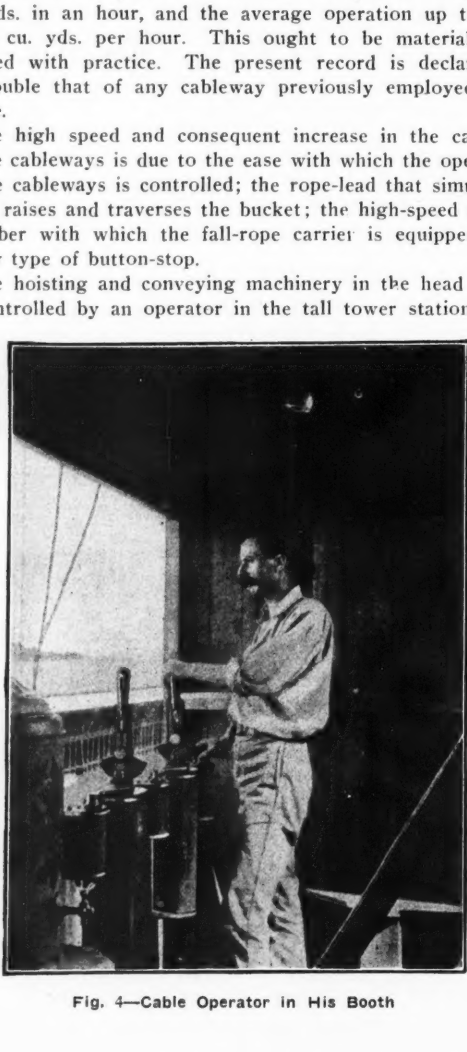


Fig. 4—Cable Operator in His Booth

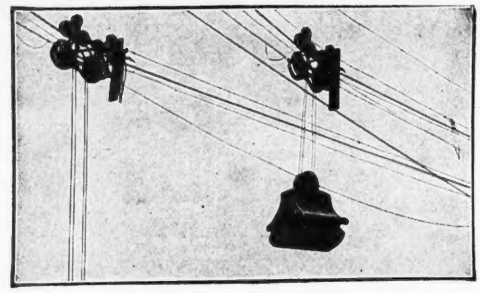


Fig. 5—View of Carriage and Buckets Showing Fall Rope Carriers

an elevated platform commanding a clear view of the bucket at all times and in all positions. He controls two 150-h.p. motors by master controllers of the New York Subway type, and the air brakes by two levers operating magnet valves 800 ft. away. The physical effort of operation is so easy that the operator can comfortably maintain the high speed. In all previous cableways this effort was so fatiguing that, although it was possible to attain a speed of 35 round trips per hour with mechanical levers, this could not be sustained for any length of time.

The rope-lead which simultaneously hoists and traverses the bucket causes the latter to move in a curved line cor-

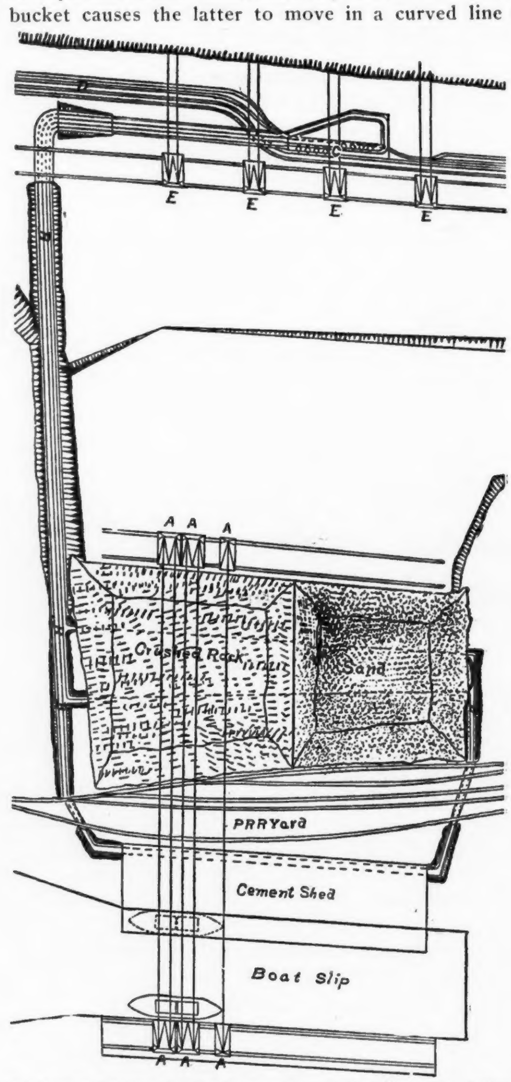


Fig. 6—Gatun Locks; A, Cableways for Unloading; B, Automatic Railway from Storage to Mixers; C, Concrete Mixers; D, Electric Railroad; E, Cableway for Delivering Concrete in Locks.

responding somewhat to the hypothenuse of a triangle, instead of moving on the vertical and horizontal sides. Considerable increase of speed and diminution of travel is thereby effected. The high-speed shock-absorber with which the fall rope carrier is equipped is the invention of Spencer Miller. It permits the carriage to travel at the unusual speed of 2,500 ft. per minute. The button-stop employed has been successfully tested experimentally with a fall-rope carrier running at the speed of 3,000 ft. per minute.

On account of the ease of operation of these cableways, considerable difficulty has been experienced in restraining the operators from racing with each other. The cableways have frequently been operated at a speed of 3,000 ft. per minute, which, being at present too severe for the fall-rope carriers, is now limited to 2,500 feet per minute. Some of the small pieces forming the heads of the fall-rope carriers are being replaced with heavier pieces which, it is believed, will admit of even the higher speed.

Another feature of these cableways which is new is that the bucket is counter balanced like a passenger elevator. Thus only the net load has to be hoisted and only enough power is required to do this and overcome friction and inertia.

The eight cableways used for putting the materials in place in the lock walls are similar in span, height, style of towers, and method of control to those for unloading the materials, but they will never be called upon for such rapid work. While they will handle the entire amount of concrete, and besides this, the wooden forms and the many tons of old rails which are to be put into the concrete for reinforcement, there are eight of them as against five of the others, and each will have much less to do. This is necessary as the placing of the concrete requires care and deliberation. The immense quantity of concrete material for the Gatun locks will perhaps be better appreciated if one remembers that handled separately it amounts to more than 3,300,000 cu. yds., while the total cubical contents of the Great Pyramid is only 3,800,000 cu. yds. Tradition says that it took 100,000 men a hundred years to build the Great Pyramid. The Gatun locks are morally sure to be finished before January 1, 1915, and may be ready for opening the canal for use in 1913, thus justifying the confidence of "that 1913 crowd."

The Maintenance of Way Department

Rail Joints

Editor, Railway Engineering:—

Our standard joint is a plain angle bar, 26 inches long, 4-hole. Our bolts are 15-16 inch rolled thread with spring nut locks.

No positive lock nut is deemed satisfactory on rail joints, as the parts of the joint work to a seat constantly, resulting in loose bolts. A spring washer serves to take care of the lost motion until trackmen are able to tighten the bolts.

Under our traffic the joints used have a life approximately the same as the steel, or from 15 to 20 years.

Yours truly,

ENGINEER, M. OF W.

Cattle Guards

Editor, Railway Engineering:—

The cattle guard matter is a difficult one. It seems that almost any guard, except the pit guard, is not proof against stock going through. We have tried triangular wood slats about eight feet long, and also the patented metallic guards, and are now using on the C. B. & Q. old boiler flue cattle guards, made by flattening old boiler flues and attaching them together with wooden strips at each end. These are doing first rate.

I notice a new electric road near Denver, owned by the C. & S., has used the pit guards, although its steam road along side is equipped with the old style slat guards.

Yours truly,

ENGINEER MAINTENANCE OF WAY.

Cattle Guards

Editor, Railway Engineering:—

I cannot say very much about cattle guards in the positive way. On our road we use entirely surface guards, on account of the practical impossibility of keeping the track in good shape where pit guards are used. I have used Sheffield and Kalamazoo types more than any others, but have also had a little experience with the Bush guard, which I believe is not now manufactured, and with one or two other kinds; but I think that the Sheffield guard or the Kalamozoo, which are plate guards and armed with sharp points, are the most effective.

It must be admitted, however, that the cattle guard is yet to be invented which is a perfect success.

Yours truly,

CHIEF ENGINEER.

Rail Joints

Editor Railway Engineering:

Our standard rail joint is the six hole angle bar, 34 ins. long with six ⅞-in. bolts spaced 5 ins. apart. On many of them we have used tail nut locks of the Verona type, but recently we have been using the Harvey Grip track bolt. We have also used to some extent the continuous rail joint 24 ins. long, with very good satisfaction. As to the life of the joints, in our service it is rather difficult to say, as our traffic is very heavy, but not very high speed, and the wearing out of rails usually requires their renewal while the joints are still in serviceable condition.

Yours truly,

Chief Engineer.

The Track Superstructure of German Railways*

By M. Blum, Conseiller Superieur Intime du Royaume de Prusse

The German railways have always devoted themselves to constructing a track superstructure which would be as resistant as possible. In particular, they have produced much in the domain of theoretical research on the resistance and the rigidity of the track. Formerly, even too great importance has been given to the results of these theoretical researches, and that explains the employment which has been made, for a very long time on a large scale, of track on longitudinals, and the numerous trials made with rails of the Barlow-Hartwich kind (Schwellen-Schienen). Without doubt these systems offer, from the theoretical point of view, certain advantages over the track with cross-ties, but they have not given as good results in practice, notably:

(1) On account of the difficulty of proper drainage of the track;

(2) Because a simple and sure method of maintaining the track gage has not been found;

(3) Finally, by reason of the large fissures which are produced in the metallic longitudinals.

So we can consider these systems as abandoned.

To-day the most importance is given to data from experience. Now, by reason of the nature of the phenomena to be examined, the observations made during the usual

*From American Railway Engineering and Maintenance of Way Association Proceedings, with Introduction by W. C. Cushing.

FIG. 1
Prussian Hessian Railways

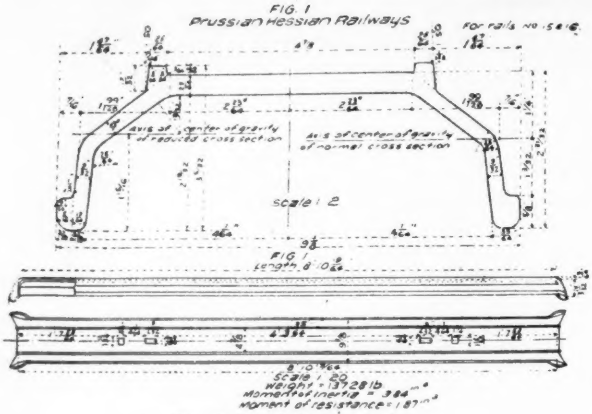


Fig. 1—Track Superstructure

operation of the railway can only produce results after a long series of years, and as, on the other hand, it is important to obtain these results in the least time possible, the Prussian-Hessian Administration of Government Railways has established, in the environs of Berlin, an experimental track on which the traffic has such a density that, in quite a short time, results will be obtained which the ordinary operation could only furnish in a much longer period.

All the projects for improvement of superstructure which might appear to promise good results should in particular be tested on this experimental track.

As has been stated above, the systems of superstructure with longitudinals, formerly much in vogue, and the rails of the Hartwich kind, can be considered as abandoned.

In this article we will only consider the cross-tie track.

CROSS-TIES.

Wooden ties and metallic ties are employed. Actually 70 per cent of the length of the principal tracks is laid with wooden ties and 30 per cent with metallic ties. The employment of the latter is rapidly developing, particularly on the Prussian-Hessian Railways, because, after observations made with the greatest care, they are superior to wooden ties from the economical point of view. This applies especially to the tracks of Western Germany which have the densest traffic.

Without doubt the metallic tie requires, everything else being equal, a ballast of better quality; nevertheless, it is more economical than the wooden tie.

BALLAST.

Besides, in Germany the greatest importance is attached to the most perfect ballast possible, even in the case of tracks with wooden ties.

FIG 2
PRUSSIAN STATE RAILWAYS

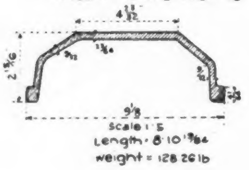


FIG. 3
PRUSSIAN HESSIAN RAILWAYS
JOINT TIE 1905

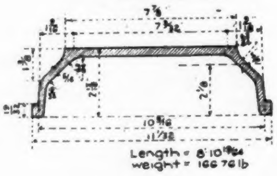


FIG 4
ALSACE LORAINE RAILWAY

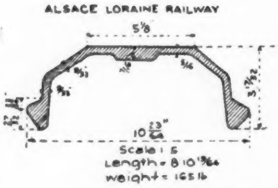
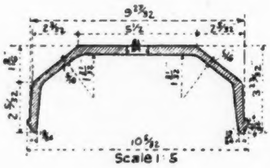


FIG. 5



Figs. 2 to 5—Track Superstructure

That is why w employ hard broken stone more and more as ballast, even in those countries where the cost is dear, as, for example, in Eastern Prussia. Experience shows that broken stone from hard rocks with sharp edges, grauwacke, diorite, basalt, even in the cases where it can only be procured at very high prices, are economically preferable to ordinary gravel. A well-ballasted roadbed, even for the track with wooden ties, contributes in a large measure to make the track stable and smooth for traffic.

WOODEN TIES.

For wooden ties preference is given to fir and other resinous species, to oak and to beech. The actual supply is divided among these three species nearly in the following proportions: 78 per cent, 14 per cent, 8 per cent. Ties of resinous wood and beech are only employed in general when injected. In the most cases, creosote, or creosote in addition to chloride of zinc, is preferably employed. Certain railway administrations still abstain from injecting oak, but

FIG 6
IRON TIE
WURTEMBERG STATE RAILWAYS

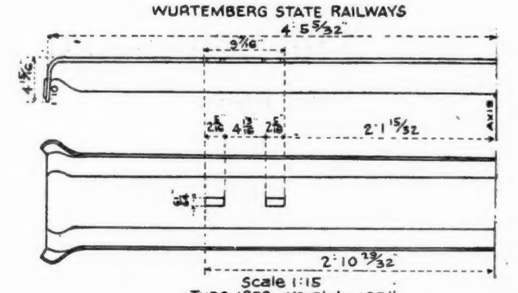
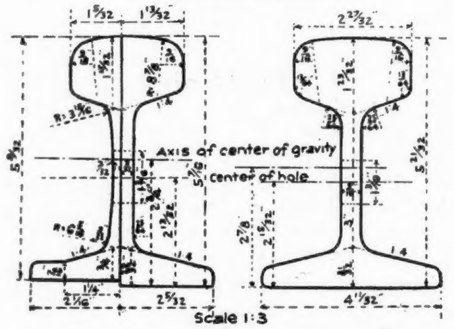


FIG. 7
PRUSSIAN HESSIAN RAILWAYS



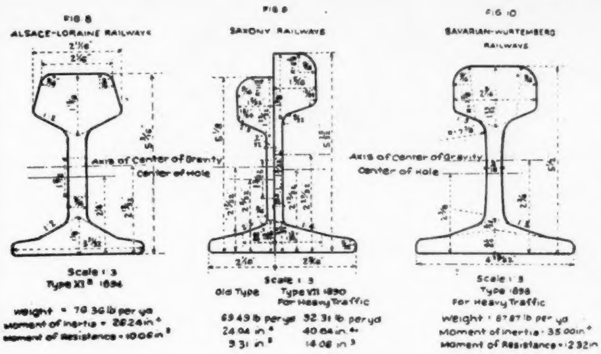
	Type 6^a 1885 For Secondary Lines	Type 8^b 1890 For Heavy Traffic	Type 15^a 1905 For Lines of Heaviest Traffic
weight	67.5 lb. per yd	82.8 lb. per yd	91 lb. per yd.
Moment of Inertia	24.95 in⁴	32.43 in⁴	37.98 in⁴
Moment of Resistance	9.4 in³	11.78 in³	13.23 in³

Figs. 6, 7—Track Superstructure

the Prussian-Hessian Government Railways inject almost all the oak ties and preferably with creosote.

From the results obtained up to the present time, creosoting is the most efficacious process. Chloride of zinc is often employed alone; it is much less costly and very efficacious also, at least in the beginning, but as it is very soluble in water, it leaches out quite rapidly and only gives a service of quite short duration, above all in the superficial rings of ties.

By stopping up the pores and fissures, creosote protects the wood against the infiltration of water. In order to avoid the considerable expense which goes with its employment, without completely sacrificing this great advantage, from 6 to 8 per cent of creosote is often added to the solution of chloride of zinc, notably on the Government Railways



Figs. 8 to 10—Track Superstructure

of Prussia and Hesse. This mixture, employed for the antiseptic treatment of a great number of ties on the said railways, has given good results.

Other different processes have been thought of for the same end. We cite:

The Blythe process, consisting of steaming the ties, before creosoting them, in the vapor of creosote water;

The employment of hot creosote: at the time when the cylinder is empty, the creosote slightly warmed is introduced into it and maintained during three hours at a temperature of 221° to 239° F.; after which the injection is proceeded with;

Emulsion: an aqueous solution of resinous soap is added to the creosote in the proportion of 15 to 30 per cent;

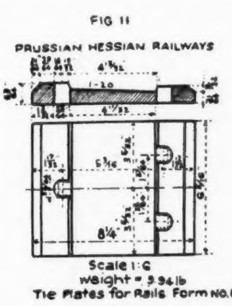
Finally, different processes consisting of withdrawing from the wood by the aid of compressed air or of vapor a part of the injected creosote (Wassermann and Rüping Systems).

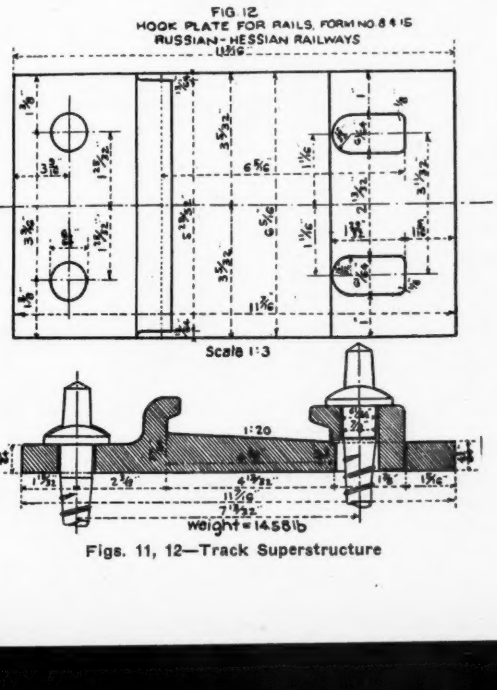
In different places, adding vegetable tar to the creosote or to the mixture of the latter with the chloride of zinc has also been tried, to render the mixture and impregnation more uniform.

Another process consists of plunging the ties into creosote simply heated, while subjecting them to a weak pressure; afterward, by a strong reduction, a part of the oil is withdrawn, and, finally, that which adheres to the surface is spread equally in the wood by the injection of vapor of water under pressure in the cylinder where the vacuum has been produced.

The results obtained with these different processes are not unfavorable, but they are not yet definite and the trials are being continued.

The length of tie varies from 8 ft. 2½ ins. to 8 ft. 10¼ ins.; the width from 9 7-16 ins. to 10¼ ins.; the thickness from 5½ to 6 5-16 ins. On the important lines, particularly on the Prussian-Hessian System, only the maxima dimensions are generally used.





Figs. 11, 12—Track Superstructure

METALLIC TIES.

The above lengths also apply to the metallic ties; however, the Baden Railways are satisfied with a length of 7 ft. 10½ ins.; but on the contrary they give greater transverse dimensions to their sections, and especially a good depth.

By reason of the various trials of the Vautherin section and with the section in the form of a hat, proposed by Haarmann, which have not given good results, ties in the form

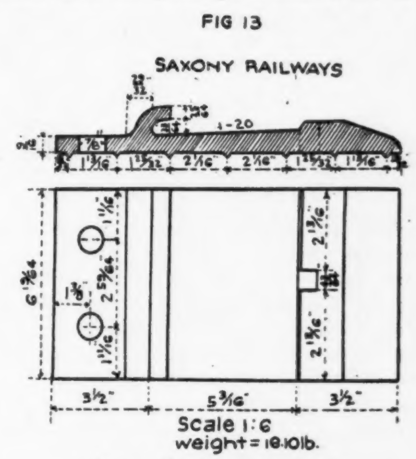


Fig. 13—Track Superstructure

of an inverted trough which hold the ballast perfectly are the only ones actually used (see Figs. 1 to 6).

The extremities of the tie are bent down by the press, so that at those points also the ballast is contained by the tie. The longitudinal displacement of the ties is thus very effectively prevented.

The weight of the metallic tie varies between 128.53 and 167.10 lbs.

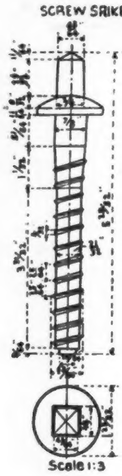
The tie, model 1907, represented by Fig. 1, with upper ribs, is employed by the Prussian-Hessian Railways in the strongest tracks with rails of form 15. The ribs serve as a support for the tieplates of which we will speak again, and hinder the creeping of the rails. This tie is probably the best of all those actually in service.

The tie, model of 1891, of the Prussian Government Railways, represented by Fig. 2, is employed with the rails of patterns 6 and 8.

The tensile strength is from 54,048 to 71,117 lbs. per sq. in. for ties of soft steel, and from 71,117 to 85,339 for those of cast steel. They should, besides, undergo the following bending test successfully.

A piece of tie 39.37 ins. long is flattened cold by light blows of the ram, then bent in the longitudinal direction so that the extremities touch and the arc of the circle is of a

FIG. 14
SCREW SPIKE



Scale 1:3

FIG. 15
HAARMANNS HOOK PLATE 1893
PRUSSIAN RAILWAYS

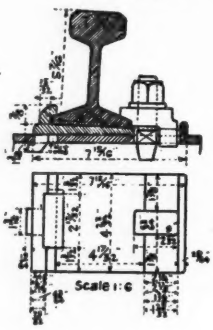
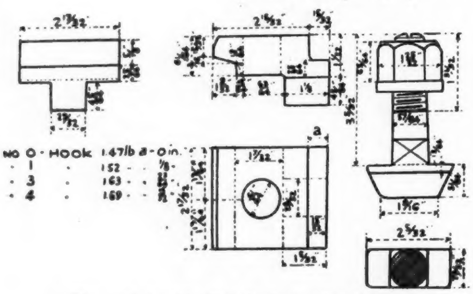
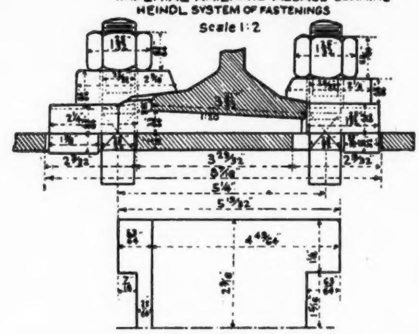


FIG. 16
CLAMP & BOLT (see fig. 15)



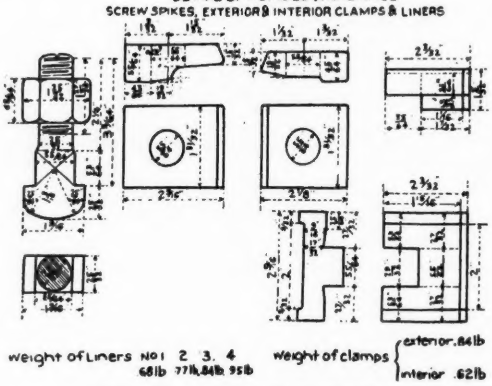
Figs. 14 to 16—Track Superstructure

FIG. 19
IMPERIAL RAILWAYS ALSACE LORAINE
HEINDL SYSTEM OF FASTENINGS
Scale 1:2



Weight of Plate = 3.17 lb.

FIG. 20
DETAIL OF HEINDL'S FASTENINGS
SCREW SPIKES, EXTERIOR & INTERIOR CLAMPS & LINERS



Figs. 19, 20—Track Superstructure

RAILS.

diameter or 2.95 ins. at most. There should be no rupture, no crack or other damage produced.

In the case of rails, only the rail with a flat base is generally employed in Germany, and it is to be observed that a notable increase in the dimensions of the rails has been produced during the last decade. Figs. 7 to 10 represent some forms of old and modern rails.

The figures show that the corner radius of the head is generally established with the radius of 9-16 in., prescribed by the "Technical Conventions of the Union," which recommend besides the employment of a width of head at least 2¼ ins., and give to the top of the form of a plane surface, or of a convex surface with a minimum radius of 7⅞ ins. On the majority of the railways this latter radius is from 7⅞ to 8⅞ ins.

At the same time that the rails have been reinforced their length has also been increased. While in 1890 we were satisfied with 29.53 ft., they reached later a length of 39.37 ft., and the Prussian-Hessian Railways only use rails of 49.21 ft. at the present time.

On the other hand, the conditions for quality which the rail still has to fulfill have become more rigorous. While formerly we were satisfied with a tensile resistance of 71,117 lbs. per sq. in., we now require that they have from 85,340 to 92,452 lbs. At the same time the total of the resistance and of the reduction of area, expressed in percentum of the initial section, should be at least 85, without, however, having the reduction of area below 20 per cent. Moreover, a bar ¾ in. in diameter, under a pressure of 110,230 lbs., should make an impression 9-64 in. in diameter at least, and 7-32 of an inch at most. Finally, the rails placed on supports 39.37 in. apart should have a deflection of 3 15-16 in. under the tup without breaking or showing any defect.

FIG. 17
ROTH AND SCHÜLER SYSTEM
BADEN RAILWAY, 1891

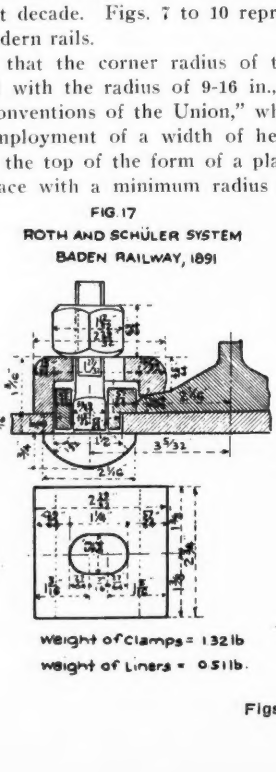
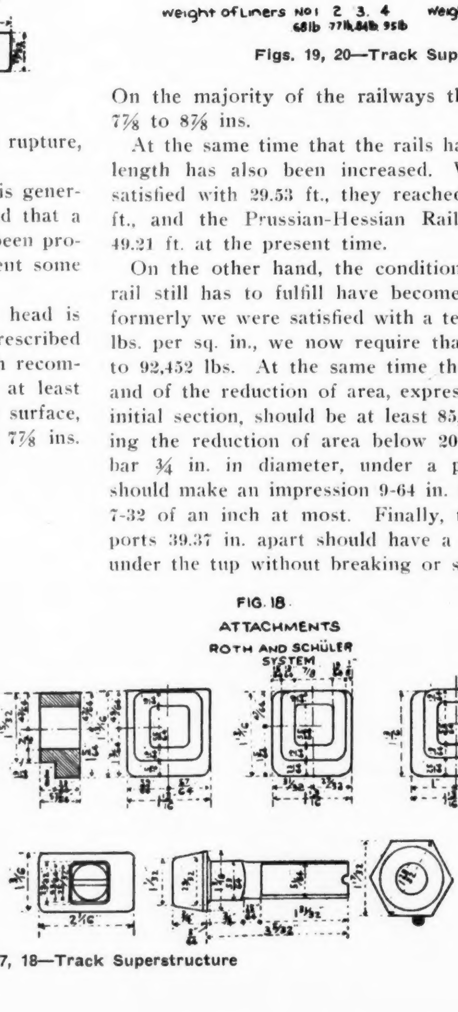
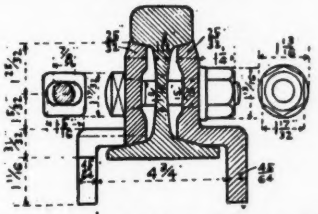


FIG. 18
ATTACHMENTS
ROTH AND SCHÜLER SYSTEM



Figs. 17, 18—Track Superstructure

FIG. 21
ANGLE BAR SECTION
PRUSSIAN RAILWAYS
Scale 1 6



Interior Angle Bars Exterior Angle Bars
Weight 33.95 lb 33.50 lb
Moment of Inertia 10.09 in⁴
Moment of Resistance 3.44 in³

Fig. 21—Track Superstructure

Thomas steel, which is almost exclusively employed in the manufacture of rails, fulfills these conditions perfectly.

The rails have been strengthened principally by increasing their height and the width of head and base. Great importance especially has been attributed to the widening of the head, because, according to the results of experience, the lateral wear of the head, above all on curves requires the replacement of rails sooner than the wear on top.

Besides a greater width of head gives larger bearing surfaces for the splices, which is important for the improvement of the joint.

In order to obtain a good joint, it is also necessary to reduce as much as possible the inclination of the bearing surfaces for the splices under the head and on the base; and the German forms of rails have been studied in consequence thereof. The inclination in question is ¼ on the majority of lines, and especially on the great Prussian-Hessian System.

The track with rails of type 15 will be hereafter exclusively employed on all the lines of the Prussian-Hessian Railways with dense traffic.

In a general way a transverse inclination of 1-20 is given to the rails, which is obtained on the majority of railways by means of wedge plates.

TIE PLATES.

These plates are employed on the wooden ties as well as on the metallic ties. It follows that it is not necessary to dap the wooden tie, nor to bend the metallic tie.

The plates are favorable to the preservation of the ties under the rail, because they materially increase the surface of support and thus reduce the wear of the wood. By employing the plates generally a safer fastening of the rails to the ties is also obtained. In fact, the plates clasp the fastening in such a way that they act in unison and together resist the forces which work against them. This result cannot be obtained without the employment of plates. Moreover, by adopting the hook plates or the shoulder plates, which serve as a lateral guide for the base of the rail, the fastening can be protected against wear from the base.

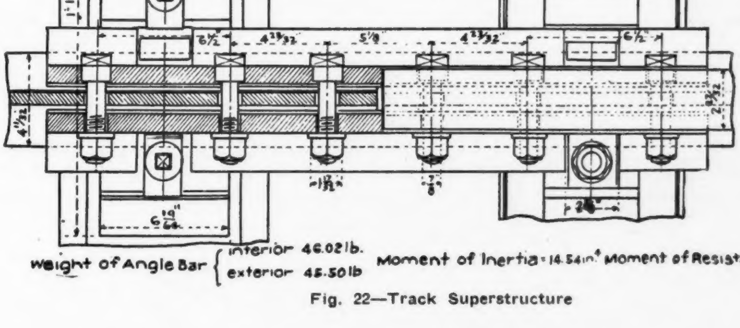
Different forms are given to the plates according to the kinds of ties and systems of fastenings (Figs. 11 to 20). So the Prussian-Hessian Government Railways, for the superstructure with wooden ties, employ shoulder plates on the ordinary intermediate ties on the one hand (Fig. 11), and on the other, hook plates (Fig. 12), which can be applied at least on the joint ties and on the middle ties with anti-creepers in order to prevent creeping of rails (see below).

On curves of 3½ degrees to 7 degrees hook plates are employed on ten other intermediate ties (oak or beech) per rail length of 49.21 ft. On grades 5-10 per cent and on 7° curves and greater, hook plates are placed on all the ties. Likewise hook plates are employed in a general way on pine ties, when the latter are not provided with hardwood trenails. Similar to what is done in France, the trenail is quite often employed in order to prolong the life of old ties.

The Government Railways of Saxony also employ hook plates (Fig. 13), but they are different from those employed in Prussia in that their lower surface is provided with teeth, which bite into the ties and thereby hinder the sliding of the plates on the ties. But this arrangement hastens the deterioration of the ties.

There exists moreover another important difference. In Prussia the hook of the plates is located on the outside of the rails, while in Saxony, the hook is found on the inside. This arrangement is theoretically rational, since the hook resists the transverse overturning of the rail. But as the inevitable differences in manufacture require a small play to be given to the fastening, the rail, in spite of the hook, can pivot a little about its edge. In consequence of this point of view the hook has been placed in Prussia on the outside

FIG 22
PRUSSIAN HESSIAN RAILWAYS, PRINCIPAL LINES
ANGLE BARS FOR RAILS NO 8 & 15



Weight of Angle Bar { interior 46.02 lb. exterior 45.50 lb Moment of Inertia = 14.54 in.⁴ Moment of Resistance = 4.71 in.³

Fig. 22—Track Superstructure

FIG 23
CROSS SECTION FIG 22
Scale 1:5

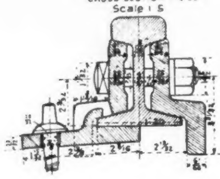
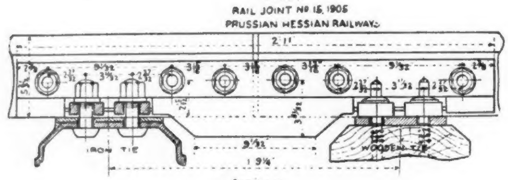
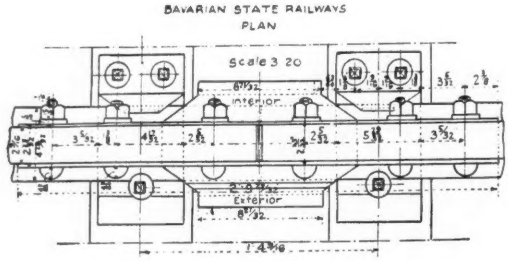


FIG 24
RAIL JOINT Nº 15, 1905
PRUSSIAN HESSIAN RAILWAYS



Scale 1:7

FIG 25
JOINT TYPE 1902
BAVARIAN STATE RAILWAYS
PLAN



Figs. 23 to 25—Track Superstructure

and the interior fastening has been arranged so that nothing is feared from the turning of the rail. Nevertheless from 1890 up to the present time, no disadvantage has been observed in the employment of the hook located on the interior in Saxony.

SCREW SPIKES AND CLIPS.

For fastening rails on wooden ties hook spikes as well as screw spikes have been used; however, in later times, the exclusive employment of screw spikes is becoming more and

FIG 26
CROSS SECTION, FIG.25

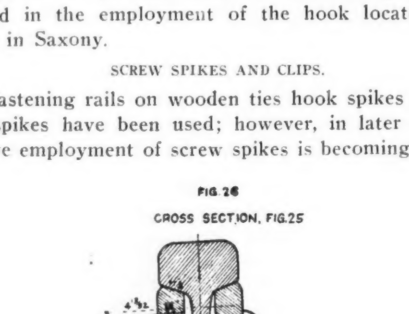
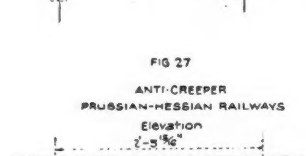


FIG 27
ANTI-CREEPER
PRUSSIAN-HESSIAN RAILWAYS
Elevation



Scale 1:15

Figs. 26, 27—Track Superstructure

more extended. So on the Prussian-Hessian Government Railways the screw spike has been employed for some years on the interior of the rail, where it is a case of resisting their overturning. On the outside, where it is a case of resisting above all the lateral pressures, hook spikes on the contrary have been used. To-day the screw spike is preferred even on the outside of the rails. For this end, screw spikes 5 29-32 ins. long are used on ties with the hook plates (Fig. 14). In the case of ordinary intermediate ties screw spikes 4 23-32 ins. long serve. Besides, with the hook plates, there are employed on the inside of the rail clamps (Fig. 12) which clasp the base of the rail and have a heel which engages in the hook plate, so as to shield the screw spikes from direct contact with the base of the rail; these clamps thus protect the screw spike against the destructive action of the base more effectively than the lateral edges of the ordinary plates.

For fastening the rails on metallic ties, plates in the form of a wedge with hooks on the outside and clamps for holding on the inside are employed (Figs. 15 and 16). This hook plate, invented by Haarmann, is provided also with a protection, which is inserted in the upper surface of the tie. In order to provide for the widening of gage on curves, as is customary in Germany, without special boring of the ties, four kinds of hook plates and holding clamps are employed.

The gage of the track is regulated up to 53-64 in. by means of the heel on the plate which is engaged in the tie, and by

FIG 28
ANTI-CREEPER
BAVARIAN RAILWAYS

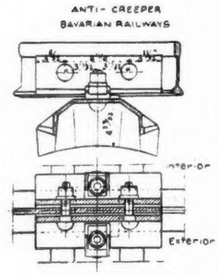
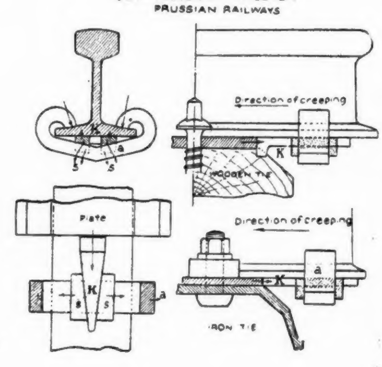


FIG 29
DORFMÜLLER ANTI-CREEPER
PRUSSIAN RAILWAYS



Figs. 28, 29—Track Superstructure

means of the projection of the clip which is engaged in the plate and whose thickness increases by 1/8 in.

The fastening of the pressure clamp to the ties is made by means of a screw bolt with a hook-shaped head. The form of the head allows of the introduction of the bolt from above across the tie and afterward turning it 90 degrees, and the strength of the tie is but little diminished by the boring. The hook of the plate and form of the pressure clamps protect the bolts from the transverse forces.

Another method of fastening by Roth and Schüler is widespread, especially on the Baden Government Railways. In the arrangement represented by Figs. 17 and 18 plates are not employed, and it is therefore necessary to obtain the transverse inclination of the rails by means of frapping or bending the ties.

The rail is held by means of clamps and gage blocks. The latter penetrate into the upper surface of the ties in order that the bolt may not be immediately subject to the transverse forces. With the ordinary appliances the gage widening can be regulated by steps of 1/8 in., with which the majority of railways which employ this method of fastening are satisfied. The Baden Government Railways have adopted a rule of widening by steps of 3-64 in. (Fig. 18) by means of the introduction of two other small pieces.

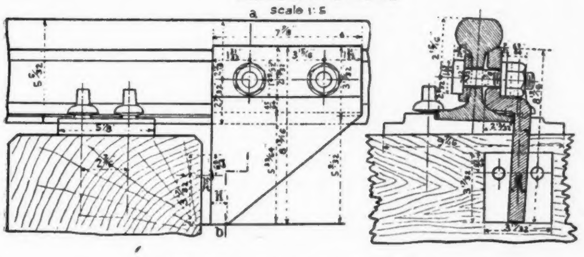


Fig. 30—Track Superstructure

Finally, we will mention the method of fastenings represented by Figs. 19 and 20 according to Heindl, and which are employed on the Alsace-Lorraine and on the Bavarian and Würtemberg Railways. Likewise in this case wedge plates, small liners and pressure clamps are used. The latter are different for the exterior and for the interior; the liners are four kinds by which the widening of the gage can be regulated by 5-32 in.; in this case the bolts are likewise protected against the transverse forces by the shoulders of the plates and by the liners.

RAIL JOINTS.

Experience shows that a good joint is of prime importance, and the German railways have given the greatest attention at all times to that question.

On the German lines, in a general way, the suspended joint has been adopted; the distance between the joint ties, which formerly was often 27 9-16 ins., has been decreased more and more. It has actually decreased in the case of the ordinary splice joint with wooden ties to 13⅜ ins., and with metallic ties to 13 ins. Extended trials have actually been made with joints which, while being suspended, have the ties very close together. In laying with wooden ties, ties placed close together by means of dowels are employed; in laying with metallic ties the double ties are employed, on which subject information will be found further along.

In general, very strong angle bars are employed as splices, and especially double angle bars, the application of which is extended more and more. For a long time their adoption on the Prussian-Hessian Government Railways has become general.

Figs 21 to 26 represent several arrangements of joints.* With reference to the joint represented in Fig. 24; it is to be observed that in the case of metallic ties, use is made of very stout special joint ties, already represented in Fig. 3, and that the splices are so long that they pass beyond the joint ties. Their assemblage is made by means of six splice bolts.

By this arrangement the complete united action of the fastenings of the rail to the ties by means of notches provided in the splices is brought about, and, consequently, the distance between the ties and at the rail joint is made invariable. This results in opposing in an efficient manner the sliding of the rails on the ties.

However, in order to react still more efficaciously against this sliding, methods to prevent creeping are employed, not only at the rail joint, but also on the other ties. At the same time the displacement of the joint ties in relation to the other ties is opposed, and excessive forces are prevented from being produced in the joint splices in consequence of the creeping.

*For greater simplicity, in Figs. 22 and 24, the arrangement of the joint for wooden ties and for metallic ties is represented in the same figure. It goes without saying that the two sides of a joint have the same kind of tie, and not different kinds of ties, as the design indicates.

For this purpose either buttress splices (anti-creepers), which clasp the fastenings of one or two ties, are employed (Figs. 27 and 28), or devices which are applied against the ties or against the fastenings (Figs. 29 and 30).

On the Question of Strengthening the Track and the Bridges with a View to Increasing the Speed of Trains*

A.—STRENTHENING OF TRACK.

If it is true that an abstract proposition has no attraction for the Anglo-Saxon mind, the question that is here to be reported upon is one that can command but scanty interest, if indeed it can be answered at all without restricting limits laid down, outside which it must not be carried.

A soluble problem seems to be assumed in the form of the question, but it is a matter for consideration whether any complete solution is possible, in view of the very general nature of the conditions and of the need of hypothetical factors, that will vary indefinitely with varying practice.

At the outset, the theory may be put forward boldly, that the strengthening of track, apart from structures to carry the track, cannot be the only condition, and may not be even one of the conditions, upon which increase of weight and speed of trains depends. It has obviously been possible, as a rapid glance over the history of Railway development will show, to produce these results to some degree, with very little, if any, regard for details of Track.

The first step in the enquiry upon which we are to enter must therefore be to arrive at some accurate knowledge of the limits of the increases in loads and speeds that are to come within the scope of our investigation, although it appears to be an axiom, deducible from the past history of Railway practice, that variations in these conditions of speeds and loads have been neither coincident nor commensurable with changes in details of equipment that have from time to time been made.

To confirm the impression derivable from the experience of earlier Railway practice, it will be worth while to quote some facts and figures, from authentic sources.

Written in 1849, there was published in 1850 a volume of information on Railway practice by Dr. Lardner (*Railway Economy*, LARDNER, 1850) that was adopted at that time as a text book, and that may now be admitted to be good evidence of the then practice. On the subject of *loads*, the author speaks of rapid developments during the preceding twenty years by which engine weights had increased from 12 to 60 tons, and other rolling stock in proportion.

Evidence of increases of speeds during the same period, though scanty, is reliable. Dr. Lardner speaks of speeds varying from thirty to fifty miles an hour. He refers to average passenger train speed of thirty miles an hour, and to express train speed over a long distance of 50 miles per hour.

At this time the form of track, that was probably quite usual, is described by Dr. Lardner as having been composed of rails of rfom 65 to 85 lb. per yard, the higher limit being used to a considerable extent. These were double headed, and were carried in cast iron chairs of from 35 to 40 lb. weight spiked to cross sleepers from 3 ft. 6 in. to 4 ft. 6 in. apart.

There is no evidence available to the reporter of the behavior of the track under such loads as those quoted, nor is the cost or exact standard of upkeep at that period to be arrived at for comparative purposes. And indeed if this last means of comparison were at our disposal, the conditions that affected the road, and by which it was judged, apart from loads and speeds, were probably so different from those existing today, that no comparison would be of much value. It may be taken for granted that the standard of condition was sufficiently different

*From paper by J. W. Jacomb-Hood, London & South Western Railway in Bulletin of International Railway Congress.

to upset any conclusion that the differences in cost of upkeep might suggest.

At the present day, total engine loads on British Railways are, quite commonly, up to 100 tons, with individual axle loads that exceed 20 tons. Upon the point of speed, there can be little doubt but that the average train journey for passenger and goods trains over distances of 100 miles and more is performed at a higher speed than 30 years ago, or that the express service of the country is on the whole faster, while the total train miles performed have certainly enormously increased in number.

These increases in loads, speeds, and density of traffic, that can hardly be seriously disputed, are performed on tracks that are, in particular detail, only slightly improved over those of the earlier periods to which attention has been drawn. Between 1850 and 1880, although the figures of increases of load and speed indicate advance, there was practically no change in track construction; and between 1880 and 1910 any improvement that has taken place has been more one of condition than of improvement by radical alteration in design.

There are of course sections of track where the rail has been increased in weight up to 100 lbs. per yard, but it is probably true that the average weight of rail per yard on the principal lines of Great Britain still lies somewhere between 80 and 90 lbs. per yard; no considerable increase over 30 years ago. The jointing of the rails has met with no drastic change, nor have the chairs, fastenings or sleepers varied in any marked degree during the last three decades.

The past history of railway track practice in Great Britain leads us then to the general conclusion that marked increases in loads and speeds of railway traffic are to a large extent independent of improvement of track, since they have taken place without any similarly marked change in track construction, and that a conservative tendency in track work has not interfered with or retarded developments in loads and speeds.

The important question now to consider is, as to whether the point has been reached when the general conditions of track are operating to prevent further increases, and if the answer to this inquiry is affirmative, it will then be cogent to determine for what loads and speeds provision may have to be made, and by what improvement in details of design, or of the practice of maintenance of track, these increases are to be made possible.

There is no reason to suppose that the increased speeds and loads that are under notice will be those due to a change in system of traction. The change from direct acting steam engines to electro-motors as a means of haulage, does not appear to be a contingency for which provision has to be made on British railways. Were this otherwise, it might be necessary to take account of such effects of speed and load as were produced in the high speed electric railway trials at Zossen, Germany. But reference to these trials, though useful as a means of understanding the behavior of track under extreme conditions of speed, is not important in relation to different conditions of haulage.

Such conditions as are last referred to, are certainly not indicated as imminent in general practice on British railways, and can be disregarded in this inquiry in favor of more reasonable and probable increases in loads and speeds.

Dealing first with the question of loads, it will be sufficient to consider the limits of space within which locomotive steam engine design is possible, and assuming that this machine is to be regarded as the means of producing the maximm incidence of load on track and works. The construction gauge of railways in Great Britain, giving the loading or running gauge, may be taken as permanently fixed, in view of the large interests that would be involved in any alteration. Locomotive design is already spoken of as being hampered by the restrictions of the running gauge, or in other words, the size and power, and following these (presumably) the weight of machines is reaching, if it has not already reached, its limit. Increased adhesion may improve the power of machines to haul heavy loads, but such loads, would be spread over more axles, and it seems improbable that individual axle loads will be much affected. The locomotive engine itself will almost certainly be limited in maximum axle load to say 22 tons, at least for many years more. But it will be recognized that the extended distribution of load here suggested can be disregarded in our inquiry, except in respect of its effect upon the service of the track; and that the loads that are suggested as the limit to which British practice can for many years attain, are already quite general.

But the speeds that may have to be considered stand upon a somewhat different footing. In their case the limited area of load gauge, that must have an effect, and an immediate effect, now that the gauge area is practically exhausted, in that it must interfere with the tendency to increase axle loads, need not and probably will not seriously hamper railway practice in its attempt to meet the natural and general demand for increased speed. It is a matter of conjecture only, as to whether the increase that may be anticipated will be general, or whether it will be limited only to passenger traffic, but in either case, it will be posssible only by reduction of the total loads hauled, and will have no effect upon the maximum axle load question.

It is not unreasonable to suggest that railways in Great Britain may have to anticipate overall speeds including stops for fast passenger traffic on long journeys of, say, seventy miles an hour, and this will certainly involve maximum speeds, at favorable sections of the journey of at least 100 miles an hour. The reporter suggests that the above quoted speeds should be taken as the limit of increased speed upon which the question of strengthening of track has to be considered.

It should here be made clear that the limits of load and speed that are suggested above as those that govern the inquiry under question II, are distinct from, although they have a bearing upon, the effect upon track due to increase in intensity of service. An attempt will be made, at a later stage of the inquiry, to show that this is a most important consideration, and that it is intimately connected with increases in loads and speeds, but it is a consideration that may be regarded by the hypercritical as being outside the reference in question II.

Before proceeding with an analytical examination into the details of design and disposition of track that may be possible to meet altered conditions of load and speed as specified above, it will be instructive to note the result of inquiries and experiments conducted on certain French railway systems by Mr. G. Cuenot, as published by him.

This eminent investigator appears to have initiated his inquiries into the behavior of track under load, with the express object of making reports from the comparative behavior and economical efficiency of various classes of sleepers or cross ties.

His earlier investigations were directed towards the exact observation of all the possible deformations of track, and from these he proceeded to enquire into the causes that led to them.

In his able work, that has been so admirably translated into English by Mr. Cushing, chief engineer, maintenance of way, of the Pennsylvania Lines West of Pittsburgh, he sets forth the course of his experiments, and the results of each, together with the general conclusions to which he was driven as a result of them, as to the direction in which maintenance-of-way engineers should proceed to secure tracks that are more perfectly fitted for heavier and faster services.

Special attention is drawn to these investigations, and to the record of them, inasmuch as the reporter is not aware of any similar work, or of work on such sound, simple and accurate lines, having been undertaken previously, and because he believes that the facts thus brought into prominence are of primary importance in arriving at a solution of any of the problems involved in the question now before the Congress.

Mr. Cuenot summarizes the principal deformations which track may undergo as arising out of the following causes:

1—Creeping.

2—The reduction of gauge on straight sections of line.

3—The spreading of gauge on curves.

4—The compression of the tie at the supports.

5—The tearing out of the fastenings, and

6—The poor holding of the joint.

He goes on to add: "I have shown that all these deformations, which when taken singly, have only a small influence, exercise, in the aggregate, a considerable effect, as much from the point of view of limiting traffic as from facility of maintenance, and that they prevent the increase of speed on all sections of lines where that increase is desirable. Two principal causes act to produce these deformations: the bending of the cross-tie and the longitudinal movement of the track. And after a recapitulation of the facts that he has proved by experiment, he arrives at the conclusion that: "In order to have tracks in a condition for supporting a heavy and rapid traffic, there are necessary:

"First.—Cross-ties extremely rigid, two to three times more than those actually in use, which excludes in every case the employment of cross-ties exclusively of steel in the form of a trough.

"Second.—The laying of the track with a cross-tie under the joint, that cross-tie being followed and preceded at 11.81 inches with cross-ties equally rigid.

"Third.—The use of reinforced plates."

How far these conclusions are justified, and to what extent in these or in any other directions improvement of existing practice, to secure the desired result, is called for, it will be the object of this report to discover.

The reporter proposes to divide his subject into two general divisions, the first dealing with the design and disposition of parts that go to form the track, and the second, taking into account the details of the lay-out and maintenance of the track when under service.

1—Design of Parts.

The first division of the subject seems to fall easily into subheads, as follows: (a) rail, (b) joint, (c) fastenings, (d) cross-ties, and (e) ballast and formation: each of these sections being of individual importance, as contributing factors to the whole.

(a) rail.

It must be realized at the outset, that the effect of increased speed and increased loads upon all parts of the track equipment and particularly upon the rail, however carefully that increase is defined, is not within the province of exact knowledge. But that higher speeds and greater loads will affect the rail in some way is certain, although the direction and extent of the effect must be at present uncertain. On the one hand, the strains due to heavy blows upon the rail will be intensified by higher speed, while on the other, the effect due to dead loads will be less sustained. But apart from increased speed, increased loads, especially if accompanied, as they may be expected to be, with increased intensity of service, must in some undefined way, affect the life and therefore the wear of rails. It has recently been stated on good authority that evidence is accumulating to prove that the life of a rail is a function of the number of wheel loads that pass over it.

Will an increase in the weight of the rail be all or only a part of the improvement necessary to meet the changing conditions? There must, in this direction too, be much uncertainty as to what is absolutely needed. Doubtless, as a general proposition, the heavier the rail (assuming proper disposition of metal in the section to secure satisfactory manufacturing conditions), the better the ability to resist the unmeasured and increasing strains that may be anticipated from increasing speed and weight of service, and the lower the cost of maintenance. But economical considerations demand that some inquiry should be made with a view to securing that unnecessary expense is not incurred in this, one of the most expensive directions. Experience and mathematical analysis both suggest that a properly designed and supported rail weighing 100 lbs. to the lineal yard cannot be stressed beyond a safe working limit with the loads carried at the speed that we have in mind in this enquiry.

Is an alteration in profile as regards the section of rails likely to produce good results? Here again the general consensus of English opinion seems to consider that the sections lately put forward by the English Engineering Standards Committee represent the last word that need be said in the present generation upon this point, as affecting English practice. No large amount of space need be wasted on this part of the subject, although its dimensions are practically illimitable, yet it must be touched upon.

The question of profile of section presents itself under two aspects, that of the user as distinct from that of the manufacturer. Both aspects need consideration, and must find common ground to secure general acceptance. Both user and manufacturer have a common responsibility, although each is sometimes inclined to attempt to shift the burden upon the other; while each can offer some particular experience, denied to the other, towards the solution of the questions involved.

The user will always be inclined to seek, for high speed and heavy load purposes, a rail that is stiff as a girder, and his instinct will be sound. He will therefore ask for the deepest rail that the distribution of metal in the section will allow. And as economy in service is a feature that will directly appeal to him, he will also demand a large percentage of metal in the head to allow for extended wear. With a strong sense of the importance of these two physical features in his mind, he will still demand from the manufacturer a quality of steel throughout the rail that is difficult, if not impossible, to supply.

The manufacturer in his turn may have to ask for some modifications of section from the extreme limits of section that the user would suggest, if he is to provide a rail of such homogeneity as will produce the best result in lasting service.

A compromise between these two conflicting interests has resulted in the British Standard Section and Specification of Composition, but to give the best results for high speeds, it is doubtless desirable that a section with a greater total depth than is there laid down, without much disturbance of the relative proportions of the head and foot, should be adopted.

Another feature that directly concerns the rail in its relation to the question of quicker and heavier service, is that of the desirable rail length. Leaving out of consideration for the moment, the closely related question of joints, and assuming that practice demands some limit in length for each particular rail, it will be of interest to consider the bearing of rail length upon the economics of increased speeds and loads, and the ideal length at which railway practice should aim at the present time. This question again is to a large extent complicated by manufacturing conditions, and these will first be dealt with.

The early history of steel or iron rail rolling seems to indicate that convenience in manufacture has chiefly dictated the lengths in which the finished product has been delivered to the rail user, but a hint that the greatest length conformable with reasonable convenience in manufacture and transport has been suspected as being desirable, is given by the fact that standard rail lengths have tended to increase from time to time until, at the present time, it may be said that the large majority of rail deliveries are in 30-foot lengths. This magic length, so far as the reporter is able to gather, has but two strong recommendations: it is a convenient number of yards, and in rolling mill practice, a steel bloom will cut economically into three such lengths. Plant for cutting and handling rails of this length both in the mills and during transportation, having been laid down, the length has been generally accepted as convenient, but among other improvements that have been suggested by the practice of more than one Company, a rail extended to the greatest practicable length has to be taken into account. If for no better reason the longest possible rail commends itself on the ground that joints are reduced in number to a minimum, a policy that is dictated as much by economical reasons as by a desire to eliminate possible mechanical weakness in the continuity of the track.

It would seem desirable, if possible, for railway companies to arrive at a satisfactory agreement as to the maximum lengths to which rails can be cut. A general consensus of opinion on

this head would encourage the development of suitable transporting and handling plant, and would do something to modify the tendency on the part of the manufacturer to make an undue claim for special cost in connection with rails longer than usual, a claim for which there would seem to be, in ordinary circumstances, but little ground.

Experiments with 60-foot rails are said to have been made, but the result, if conclusively satisfactory, is not known to the reporter. But if the transportation difficulty with 60-foot rails was overcome, there would still remain the unsatisfactory question of the large proportion of shorter rails that would arise at the rolling mill as a residue from each bloom.

It is probable that a middle course, by which the transportation trouble is limited, and the wastage from the rolls is reduced, will recommend itself, in which case a length of 45 feet might be generally adopted.

(b) Joints.

It is difficult to estimate the value of the contribution that joint design makes to the question of the efficiency of track to sustain increased speeds and loads, but there will probably be general agreement with the view that all and every joint fitting that has come within the range of practical utility, whatever its inventor may have claimed for it, has sooner or later been open to objection, and has developed a source of weakness. It is indeed not too much to say that, in British practice at least, and with our present practical experience, the joint is, and is likely to remain, the weak spot in our track practice. It is, fortunately, not necessary for the subject to be dealt with very fully here, because it is one that is being treated by itself at the hands of another, and more experienced reporter; at the same time the general bearing of the question upon the capacity of tracks to do higher duty, cannot be left entirely untouched.

British practice adheres very closely, either by reason of an inherent conservative tendency or because experience indicates this as a wise course of action, to the early and quite general form of fishplates or splices that fit the web of the rail on either side. Variations, involving the deepening of the plates, by the addition of a bottom member, have been numerous, but do not seem to have settled into any permanent general form, or to have retained any great popularity. And the reason of this failure, if such there be, to perpetuate divergence from the early type, would appear to be that the same weakness after extended wear, seems to make its appearance in spite of the expensive attempts that have been made to obviate it.

Most of the plates that have been in general use, whether they nearly approach, or are quite widely divergent from, the primitive type, are successful in securing alignment of the continuous rail surface over the joint for a shorter or longer period after they are first put into service; but by slow degrees and with unerring certainty, the joint gives way in its effort to sustain firmly the varying and intermittent stresses in the rail. As soon as any movement in the parts begins, the deterioration of the plates as a support to the rail ends is rapid and obvious.

If this is the condition with the service of today, it will be clear to the conference that the more exacting service under consideration will need better means of joint support than present practice seems to offer.

It would seem to be desirable to draw attention here to the far reaching effect of the weakness in track due to inefficient joint design. From the maintenance of track point of view alone, the effect is serious because the heavy cost of rail renewal is undoubtedly increased, by reason of the failure of rail ends in service, while the much larger proportion of the rail length remains fit for more extended use. And this renewal, necessitated by the breakdown of a minor part of the whole equipment, is not confined to rails only. Disturbance at rail ends produces chair wear at rail middles, and tends, in the long run, to sacrifice every member of the track structure. Then the undue wear of rolling stock that would be otherwise obviated, is an item of expense that cannot be neglected, and above all stands the increased track resistance that follows track in bad level and quickly wearing wheel stock.

All these defects must have a definite bearing upon the profits or otherwise of the transportation business for which the tracks serve.

It has been frequently suggested that the general tendency to rail-end destruction due to weak suspended joints, might be successfully met by abandoning the principle of suspension for a joint that is directly supported. British experience does not give much hope of relief in this direction, although it must be confessed that this has been, hitherto, limited in extent.

Mr. Cuenot's investigations, on the other hand, certainly do point to the possibility of the joint difficulties being reduced by the application of the principle of a direct support, and so sound are the reasons for his opinion, that it seems to the reporter as likely that a suitable design for a supported joint will become a necessity in the case of tracks designed for improved services. If it should prove to be possible to find a really satisfactory supported joint that will stand up to its work, the objections to staggered or broken joints in the opposing rails of track will largely disappear, and an economical if not mechanical advantage to running will at once accrue.

The more minute details of joint design, having but little bearing upon the question at issue here, can be left for the fuller treatment that they will receive in the case of the special report that is to be made upon this subject.

(c) Chairs and Fastenings.

Whether the high service rail of the future is to be carried in a chair, as an intermediate member between rail and foundation, or not, the details of the fastenings by which the rail is securely held will certainly need the closest attention with a view to improvement on present general practice. For reasons connected chiefly with cross-tie considerations, it is possible, and, from some points of view, perhaps desirable, that the cast iron support of large superficial area, at comparatively wide intervals, in which the rail has been used to sit as in a chair, will, or should, give way to a lighter fitting in the nature of a sole plate designed chiefly from the point of view of fastenings. Such a change as this would naturally involve a change in the form of rail, that would then nearly approach to American practice, and the author is not convinced that this would be otherwise than a sensible improvement for faster running, although first cost might be increased.

Students of English railway track practice cannot forget that cast iron chairs were originally introduced with the principal object of carrying a rail that was rolled with two running surfaces, that would be capable of easy reversal in position at intervals. There was the additional advantage that became evident as experience crystallized practice, that a cast iron chair of large area provided so good a support for the rail upon the cross-tie that the spacing of the ties could be somewhat increased without increasing the crushing effect of the rail upon the soft timber surface.

The first reason for the adoption of chairs has now entirely disappeared, and the second must have a decreasing effect upon the question as it becomes evident that, however stiff the rail may be as a beam, the greater the number of supporting ties below it, the more satisfactory the result from the points of view both of avoiding deformations, and of economy in upkeep.

Neither must one of the main facts be lost sight of, that the introduction of an additional member or unit in the whole equipment, that can conceivably be dispensed with, introduces not only an element of extra expense, but of extra wear, and of additional vibration and noise.

It is, no doubt, generally supposed that the secure keying of the rail within the chair jaws produces a practical homogeneity between the two members. Experience does not bear out any such theory as may be proved by the abandonment of the double headed rail practice, due almost entirely to the damage inflicted by the chairs on one of the running surfaces of the rails when in reverse position.

But it cannot be claimed that the continued use or the disuse of the chair is a point of serious importance as bearing upon the question at issue.

If it should turn out, as the reporter thinks probable, that a deep flat bottomed rail proves by experience to give a more satisfactory result than one of bull headed form, it may still be necessary to provide a sole plate as a bearing under the rail,, in circumstances where the softwood timber that can be most economically employed in Great Britain has to be retained for cross sleepers.

In any case, what is of real importance is that a form of fastening should be used that will intimately bind and secure together the rail and the cross-tie, and in a manner superior to that generally adopted, so that the working of the whole track upon its bed, action that cannot be entirely avoided, in any service, may be limited as far as possible. The reporter believes it to be capable of demonstration that if the whole track equipment could be combined more rigidly as one entity, many of the difficulties and much of the expense of maintenance would disappear.

So far as information on this point is available, the only attempt to secure perfection in this respect has been made by the Great Western Railway Company, by a combination of a special chair seating on the timber, and a stout through bolt capable of being periodically drawn up by the tightening of a nut on its upper end. This arrangement, that has now survived the experience of about ten years, is said to be successful, and it is at least more promising than those more incomplete efforts towards security that have prevailed for many years in the employment of a coach screw or a spike and trenail or both together in variously combined forms.

No fault can be found with the coach screw fastening when new, but as the hold upon the timber fibre relaxes with time, and the natural deterioration of the material, working is set up that must tell against the stability, and therefore the high service of the track equipment. For the spike, either with or without a hollow hard wood trenail, the reporter is not prepared to claim any advantage beyond low first cost.

An improveemnt upon the coach screw as a fastening that is promising, and that may secure the practical advantages of a through bolt at a lower cost, is the armoured screw thread in the timber provided by the Thiollier Spiral. This fitting is being used to advantage, and cannot be disregarded.

(d) CROSS TIES.

This unit of the track equipment would seem to offer more opportunity for close consideration with a view to alteration in general practice that any other detail, when attention comes to be given to the means by which existing track practice is to be made suitable for increased speeds and loads.

Assuming the form and material of cross ties in general British practice to remain as now, there would appear to be no single dimension of the timber scantling that will not bear close investigation with the possibility of improvement. The width of the timber to secure greater foundation area may be increased with advantage. The depth may be made greater to afford opportunity for a more secure fastening, but whether the advantages of such alteration are at all commensurate with the increase in cost that would be involved, is doubtful.

The length of the cross-tie offers more promise of advantageous alteration if the investigations of Mr. Cuenot are a safe guide to improved practice, and as the alteration indicated will save expense, it may be the more readily considered.

The experiments referred to seem to show that the elastic qualities of timber ties produce depressions early in the life of the bedding in the less elastic ballast foundations, that are aggravated by the length of the timber cross-tie being extended. It has been made clear also that there is a critical length of timber in cross-ties, relative to gauge, at which the depressions in the ballast are at a minimum, and such a length for the British gauge of 4 ft. 8½ in. is thought to be much less than the standard length of 9 feet. Stiffness or rigidity in the tie, as in every other detail of the equipment, to resist disturbance under load is the desideratum, and it would seem to follow that alterations in the standard dimensions of timber ties, to meet the conditions referred to above, would involve (say) 10 inches wide, 6 inches deep, and 8 feet long, as most suitable for a track devoted to high speed services.

But the evident urgency of securing the utmost rigidity in cross ties drives the investigator to consider more closely the question of the substitution of some less elastic and more rigid material than is commonly the practice in English speaking countries.

The dissatisfaction with timber as material for cross ties, arising from the causes referred to above, is not felt at the present juncture as a condition that is by any means novel, and it is probably near the truth to say that all English companies have been looking for the use of a material that will be at once more lasting and more rigid, during the period of the last thirty years, although the majority of the experiments have been confined to designs of cross-ties constructed entirely of mild steel plate. These experiments too, have been of so diversified a character that a conclusion of no little value can be arrived at, as to the possibility of the problem finding a solution with steel as a material used by itself. Objections to this material in any form are by no means wanting. It is not decidedly proved that the slightly longer life of steel ties, as compared with treated timber ties, is a satisfactory set-off against the larger cost of the former. The earlier anticipations of a greatly extended life for steel ties, as compared with timber, have to some extent been falsified, owing to the unsolved difficulty of arranging a fastening for the rail or chair on the tie, that will resist the heavy wear to which it is subjected.

This last difficulty may be said to have been inherent to the design of all the various types of steel sleeper that have been in us, and it is to this that the failure to secure general acceptance and more extended use is principally due.

Comparative experiments directed to measure the elasticity of some of the types of steel cross-ties prove them to be superior to timber in their capacity for maintaining the track in good alignment, but the superiority is not strongly marked.

The cross-tie of the future that will bring about as great an improvement in the speed and load capacity of tracks as can be due to this particular unit of the equipment, must have this characteristic of rigidity even more strongly marked. Provision for securing fastenings either of rail or chair must be satisfactory and lasting in its tenacity, the weight as affecting transportation and handling must not be unduly increased, and the increased cost as compared with timber that will inevitably follow must be counterbalanced with certainty by a greatly extended life.

To meet these conditions there are, in the present stage of development, two alternative designs of cross-tie in competition. The one of reinforced concrete, and the other of a combination of steel and timber.

It may be assumed that either of these forms can be designed to satisfy the first need for a maximum of rigidity. As to security of fastenings, the combination tie will certainly be superior. It will probably be lighter, and its life will be within the region of computation with greater certainty.

Indeed the concrete sleeper with steel reinforcement is at the present time in too early a stage of its development to enable the reporter to speak of it as being other than a remotely possible means of improvement.

The designers of the various forms that have been offered for trial in Great Britain are basing their estimates of value upon a length of life as to which there can be no satisfactory assurance of accuracy, and this consideration must have weight to the exclusion of all others of an equally doubtful character, such as the permanent security of fastenings, the convenience of transportation, and—most important of all—the cost.

For the above reasons, the reporter does not suggest that the realm of practical politics offers any other serious solution of the cross-tie problem than the compound sleeper, in which the

load is supported and the gauge maintained by a strong form of steel girder in duplicate, such as channels, or other similar section, containing between them timber blocks that will form a bearing for the rail or chair, that offers the best opportunity for fastening, and that is renewable at small cost upon failure. In this form of cross-tie, the unloaded middle will be a skeleton requiring no tamping and offering a minimum of resistance to the impressed ballast. For this reason, it will have a decreasing tendency to bend, over the center, any downward movement due to permanent depression of the inelastic ballast thus taking place throughout the whole length of the tie.

A compound sleeper of this description, can be designed to be no heavier than existing practice makes necessary. It should have a life as long as any other form of tie, and should be no more costly.

(e) BALLAST AND FORMATION.

The notes preceeding this have indicated the sense of importance that is to be attached to rigidity and freedom from movement between the parts, throughout the whole of the superstructure of the track. If this is true of the diverse fittings of the superior equipment, it must be of still greater importance when the inferior foundation comes to be considered.

In the same conection, the trite remark that water is the enemy of good track will bear repetition here as pointing to the fundamental need of drainage being regarded as one of the most important objects of track practice for high as well as for any service.

For these reasons, the class of material that is to be used as a support for the cross-ties, and the rails they uphold, becomes a matter of primary importance.

The gravels and loamy shales that in certain districts have to do duty for ballasting material are so defective in drainage properties, that in considering the requirements of high class track, they must be ruled out of permissible use. Extended experience points to the high qualities of strong stone or granite broken equally and regularly to nodules that will pass a 2½ inch screen but that will be excluded by a 1½ inch screen, and it is certain that the best track requires material equal to this, although the cost may prove heavy in some districts. Cross-ties that are once well bedded on a foundation of such material not less that 45 inches in thickness beneath them, will retain their firmness for a longer period than would otherwise be the case.

Of little less importance is the necessity for providing and keeping the formation in a clean and regular condition for the quick dispersal of the surface water. Where formation has been allowed to become irregular and water-logged, the cost of work involved in newly forming and draining will probably be well repaid.

2. MAINTENANCE AND ALIGNMENT OF TRACK.

In the consideration of the question now before the Congress, it will be well to emphasize the point that perfection of design as regards the track equipment can be entirely neutralized by inattention to the daily and yearly routine of unkeep to maintain the tracks so designed in the best possible order for the more exacting conditions of service. It will be readily recognized, and should be constantly remembered that maintenance in high condition is of the first importance to well designed, as to any, equipment, and that economy can be more certainly secured by keeping that condition, than by adopting expensive details of outfit, and afterwards allowing track so constructed to fall into disrepair.

This consideration introduces the important question of the extent to which expense of daily maintenance can be saved by design of parts. The reporter is not able from the information he has collected to arrive at any means of replying with a great degree of certainty to this inquiry. It has been assumed in the practice of some English companies that certain alterations in practice, such as an increase in bulk of the general track equipment, the adoption of a heavier rail or of more secure fastenings, does decrease the cost of maintenance, but in the nature of the conditions, it is not possible to produce definite results that can be accepted as undoubted proof of this. Nevertheless, there is a general concensus of opinion that, by one means or another, as regards the adoption of a more perfectly fitted and designed, and of a generally heavier, equipment, economies in the total cost of working, if not of the upkeep of tracks alone, is certainly secured, and the reporter endorses that opinion.

But whether the expense as compared with less careful practice is more or less, the necessity to secure good upkeep, if the conditions of load and speed are to be increased, is quite beyond question.

As soon as tracks have been laid, under conditions of design and material however good, and have come into service, there will always continue to be a steady deterioration, varying in degree according to the length of time in service and perfection in design and construction, but inevitably, towards a distortion of the line, and interference with the perfect alignment in direction and level. No means can be conceived that will entirely obviate their tendency, and yet it is a condition that militates directly against the capacity of tracks to do the best service.

Every vertical depression or horizontal distortion on the rail top originates a series of latitudinal or longitudinal oscillations in the rolling stock, that increase track resistance, add to the wear of parts of both stock and track, and—a still more important consideration—disturb the equality of load as between opposite wheels or contiguous axles, in such a way as to become in extreme cases a source of danger from derailment. As speeds and loads increase this tendency towards a condition of positive danger increases rapidly, making it of greater importance that no effort should be spared to aim constantly at the maintenance of perfect alignment in tracks.

The principal means by which this end is to be attained in tracks laid in accordance with British practice, is the consolidation of the supporting ballast by tamping, so that the displacement under load that is constantly occurring may be neutralized. Tamping, a practice so general, and to all appearances so commonplace, is in reality, and in spite of its seeming simplicity, an important and delicate art, about which sufficient care and thought has not always been expended. The exact locality of the areas under the cross-ties where the consolidation of ballast has to be greatest is a matter of considerable importance. The degree of consolidation is another detail that requires minute care if the best results are to be obtained. In this connection it may be predicted that the demands of the future will make it necessary to conduct and arrange this important operation on better understood and more accurate lines than hitherto, and that advantage will be taken of the mechanical means that are available as a substitute for the beater and shovel.

Where lines are curved, it cannot be doubted that the need for the most perfect alignment is the greatest. Irregularity of curvature produces conditions that rapidly become dangerous with increase of speed owing to the variable effect of lateral forces. Curves that are of quite short radius can be passed (given a satisfactory entry and exit), with comfort and safety at high speed, if the regularity of curvature is satisfactory, whereas defects in curvature may become a hidden danger.

Lines laid to circulars arcs should be examined at intervals, in order that the irregularities in curvature, that will inevitably arise in course of time, may be corrected, unless

points in the true curve are permanently established, by which curvature may be kept constantly true.

Where lines are laid to circular arcs, and of high radius in particular, it is recognized as practice of the highest importance, that the entry to the arc from the previous alignment be by means of a spiral transition within which the superelevation of the outer rail may be attained, and by which means the effect of the sudden application of lateral forces, tending to overturning and to derailment, may be obviated.

It remains only to give consideration to the difficult question of superelevation of the outer rail on curved tracks, a subject that is complicated by the various points of view from which it can be considered.

It will be readily accepted that the only object and effect of superelevation of the outer rail is the neutralization of the natural action of centrifugal force as applied to a body passing round a curved line. It is not so readily appreciated that there are forces other than centrifugal, tending to derailment, against the action of which superelevation of the outer rail is no remedy, and may become an aggravation; neither is it clearly recognized at what a relatively high speed on British gauge vehicles can safely pass round a curved line entirely devoid of any superelevation.

The speed that will approach the tendency to overturn, due to centrifugal force and without superelevation of the outer rail, is so high that it is beyond the reach of practical considerations, and is probably above the limit at which derailment outside the curve will take place from other causes.

Superelevation has, therefore, less importance from the point of view of safe passage on curved lines than when viewed in some other aspects.

Excessive superelevation on the other hand not only introduces practical difficulties when there are complicated track fittings, but tends to lower the limit of speed that will introduce danger from causes arising out of a reduced load on the outer wheel.

But a moderate elevation of the outer rail of the track, to a point that does not introduce trouble at low speeds, does tend to a sense of comfort in the passenger, although it demands little consideration from the point of view of safety. The exactly suitable amount to be provided being arrived at best as the result of experiment.

With a sound track, on a well drained foundation, maintained in good line and level, and with the entrances to and exits from curved sections properly prepared by spiral transitions, trains may safely attain speeds in miles per hour on the curved sections (within reasonable limits of curvature), equal to eleven times the square root of the radius in chains. It should however be added as a qualification to this opinion, that as the character of the rolling stock plays some part in satisfactory performances of this nature, any defect or abnormality arising from this cause must not be disregarded.

But this need for nicety of maintenance, upon which the reporter desires to lay so much emphasis, is not occasioned alone by the increase of loads and speeds that is the underlying consideration of this report. It arises as much from the assumed necessity of providing for a bulk of traffic that is growing denser as well as heavier and faster.

If it was possible to consider, solely, a condition where there was a large increase of individual load, accompanied by a corresponding increase in speed of passage, the conclusion at which the conference might arrive with regard to this question might differ considerably to that towards which the information at the disposal of the reporter is intended to lead.

But no such assumption can be regarded as reasonable, and indeed the conclusions are entirely based upon the opposite view.

No attempt can be made here, even if such were possible, to compare the proportionate effect upon track, due to dense or frequent traffic, with that due to heavy and fast traffic. It must be accepted that both causes contribute something to deterioration against which we have to provide, and that neither are treated separately in this consideration of the subject.

The questions upon which this report is based have now been answered, in a more or less discursive way, by compilation of facts and opinions that have been placed at the disposal of the reporter, it remains only to summarize the heads of replies with a view to better definition.

The conclusions thus summarily stated, are as follows:

Assuming the loads and speeds of moving traffic that are taken as the ultimate limit in the present era of railway practice in the United Kingdom to be but little in advance of the present, the principal conclusions to which the reporter desires to direct the mind of the Congress are as follows:

1.—It will be good practice to use a heavy rail, designed to afford the greatest rigidity possible, coincident with the nearest ideal towards a perfect homogeneity of metal. The subordinate equipment being reduced to as few parts as possible but each having the same function of rigidity under continued service.

2.—The practice of a high ideal of perfection in upkeep is to be recommended even though a larger expenditure as compared with past practice is necessary.

Given attention to these two general lines of action, it may confidently be held that proper provision is made for a reasonable increase of loads and speeds, and that the increase of business that will follow from the better conditions of transportation will render the increased immediate outlay a source of expenditure that is strictly economical.

B.—Strengthening of Bridges.

The reporter has no reason to suppose, from the information at his disposal, that any methodical system of strengthening all its bridge structures, to meet the increase in loads and speeds that has already taken place and that may be expected to continue, has been adopted by any Railway Administration in the United Kingdom.

The nearest approach towards a system, in railways under British control, appears to be that of the Indian government in their dealings with the railways under their supervision. But in this case the merits of each particular structure, and the conditions of its service, seem to operate in the direction of interference with any systematic or regular course of action.

Upon English railways, it appears to have been usual to conduct investigations, at varying intervals, into the carrying capacity of their steel and iron bridge structures, testing their fitness for service by standards that have been gradually increasing with the passage of time.

In all cases where, by these tests, the margin of safety between the working and the breaking loads has shown a tendency to wear thin, individual structures have been taken in hand and have been re-built or strengthened from time to time, as circumstances, financial and otherwise, made this course possible.

And upon full consideration of the question, no other course than that indicated above would appear to be reasonably feasible.

Although the structures were originally designed to carry loads that were, whether continuously distributed or concentrated at points, distinctly lower than those to which the structures are now generally subjected, the margin of resistance to the effect of the forces produced by the loads of earlier railway history, as compared with those of today, was so ample that any general or universal increase in carrying capacity has not yet been found necessary.

Allowing for an increase in loads, as well as for loss of efficiency from fatigue and deterioration due to atmospheric action on the material, the result, in general, has only been that the working strains upon the structures, originally and with wisdom placed at a low level as regards ultimate carrying capacity, have been gradually increased, but have not yet absorbed the margin of resistance, or reached the limit of ultimate stress outside of which absolute security does not repose.

The reporter appreciates the fact that this condition is one that has a tendency towards insecurity, unless a general concensus of opinion can dictate a definite margin beyond which the resistance of a structure should not be tried.

He believes that this opportunity of dealing with the point should be seized, and suggests for the consideration of the conference that an understanding is possible on some such lines as the following:

Taking the working stress upon metal as demanded by the British Board of Trade requirements for new structures as unity, and any increase of stress as a fraction of unity, and regarding these figures as factors of safety, it might be considered to be an axiom that any structure or part of a structrue, having a factor of safety of less than 0.75, should come in for renewal or strengthening at an early date.

This is a suggestion that is thrown out to provoke discussion, and is not intended either to represent existing practice or to prejudice action in the future.

In the case of structures where the application of this, or some other method of enquiry, indicates that reconstruction or strengthening is necessary, the limit of loads for which the new or strengthened structure must be designed will be that which has been agreed upon, after complete investigations, by the Railway Engineers' Association.

These limits are held to cover the maximum development of rolling stock and dead loads that is possible within the area of British standard load gauge, making provision for resistance to impact, and for loss by fatigue and deterioration.

In making the investigations into the strength of existing bridges, it is necessary to consider the condition of the material of which the bridge is built, the alignment of the track at that point, the speed of the trains and the behavior of the girders under actual rolling loads. If on a branch line, the moving loads on which the calculations of existing strength will be based, will be the maximum for that particular branch and not necessarily those in force on a main line. If, however, strengthening or renewal is carried out, the maximum loading of the main lines will be provided for, as it would, obviously, be false economy to ignore the contingency of the branch line having, someday, to carry the heavier main line loads.

The weaknesses developed in an overloaded bridge are so numerous and various that they cannot well be classified. In very general terms, it may be said that the floors of bridges suffer more than any part. The flanges of the main girders are also a source of weakness, both in respect of the sectional area of the metal and the bearing area of the rivets at the plate joints. The shear on the webs of plate girders and the connections between the web and the flooring are often deficient in strength. In large framed girders, weakness is found in the connections of the web members to the top and bottom booms, in addition to the weakness of the flange plates of the booms themselves.

The general policy adopted, when dealing with a weak bridge, is complete renewal rather than strengthening individual parts, the prevailing opinion being against patching material which has already had a long lease of life, although this latter alternative may occasionally give satisfactory results.

The exception to the former policy is usually found in the cases of large bridges, where such can be strengthened in a fairly satisfactory manner at a moderate cost, as against a heavy expenditure if completely reconstructed. Nevertheless, it should not be overlooked that complete renewal provides for a more extended future than can be expected from the strengthening of existing work, nor should it be forgotten that girders in good condition, which have been removed from a bridge because they were overloaded, are available for re-use after repair for bridges where the span is less, or where the load can be limited.

On the Government Railways of India, where the standardization of bridge work has been carried out to a degree that would be impracticable in this country, a system has been adopted, where a series of bridges are being dealt with, of duplicating the girders in one weak bridge with the girders of a similar weak bridge and the completely renewing the superstructure of the bridge from which the girders have been removed.

In the case of the early railway bridges in Great Britain that were constructed of cast iron, the use of this material, so far as bridges under the track are concerned, having been given up, there is, of course, no question but that entire reconstruction in wrought iron or steel should take place when circumstances make greater strength a necessity.

When it has been decided to strengthen an existing bridge rather than reconstruct it, the method of execution must largely depend upon the local peculiarities and conditions, making it a difficult matter to apply any fixed rule to any particular bridge. The following broad details of work tending to increase carrying capacity may however be accepted as charactertisic of much of this class of work:

1.—By lightening the permanent load on the girders, such as replacing a ballasted and sleeper road with longitudinal baulks carrying a bridge rail, or even by substituting a lighter type of flooring to the bridge; but this method is not very far-reaching in its results.

2.—A double track is frequently carried by a bridge of two main girders with cross girders at right angles between them. This type can be strengthened by the introduction of a new girder between the two tracks which relieves the outside girders of part of their load and at the same time strengthens the cross girders.

3.—A new intermediate support can, on favorable sites, be introduced under the main girders, thereby reducing the length of the span, but at the expense of introducing continuity in the girders.

4.—On the other hand, existing continuous girders are often weak over the intermediate supports. There is usually a difficulty in lifting the girders in order to strengthen the bottom flange at those points; in that case, it becomes necessary to cut the girders making them independent for each span, and afterwards to strengthen the flanges in the center of the span where the increased stresses will be developed.

5.—Extra plates can be added to weak girders to increase the sectional areas of metal opposed to the increased forces and thus to reduce the stresses; but this method involves expense and anxiety during the operation, and there is a risk of disturbing too many rivets at one time, temporary supports to the structure being generally necessary for this reason.

6.—By increasing the depth of the girders additional strength may be secured, but in practice this operation is generally impossible because the headway is limited, above rail level, by the construction gauge, and below, by the headway required for road or other traffic.

7.—The complete renewal of the cross girders of a bridge can occasionally be carried out without interfering with the traffic by raising the rails 12 or 18 inches on temporary baulks and then replacing each cross girder by a new girder, one at a time.

8.—Cross girders are sometimes increased in depth to give additional strength, provided there is sufficient space. The connections to the main girders may be strengthened by adding gusset plates and thus increasing the rivet area.

The material used in such strengthening works is usually mild steel because it is more readily obtainable than wrought iron. But there are grounds for the opinion that, in the case of wrought iron structures, wrought iron should be used in preference to steel in carrying out repairs or strengthening.

The difficulties to be encountered when strengthening or renewing a railway bridge, are not, as a rule, engineering difficulties in themselves; they become engineering difficulties because of the necessity of keeping the bridge open for traffic, and consequently, of the work being done under the worst possible conditions. The great weights that have to be carried by any temporary works, the continual interruption due to passing trains, the night work that is often necessary, the confined space available for handling material, the interests of road or canal traffic under the bridge that have to be carefully regarded, are all factors which tend to exaggerate the least important, as well as the most important, items of the work.

Under these circumstances, elaborate precautions have to be taken to enable the traffic to be conducted with safety and without interruption. In Great Britain, a modified train service is adopted for Sundays in contrast to the Continental system of a uniform service throughout the week. The consequence of this is that much of the most difficult part of the bridge reconstruction or strengthening is done on Sundays when there is less interference with the train service and more time between the trains. As much of the work as possible is prepared during the week. On the Sunday, single line working is brought into use and the speed of all trains is reduced over the bridge. Watchmen are stationed to warn the men at work of the approach of trains, and caution signals are employed day and night to warn drivers of trains of the proximity of the works in progress. The renewal of bridges outside large stations, carrying four or more lines of way, which are fully occupied during the day, is usually undertaken either at night or on Sundays, one track at a time, complete possession of the track having been obtained for the purpose.

When a work of bridge strengthening has been completed, it has generally been found very satisfactory, prolonging the life of the bridge, and rendering inspection less frequently necessary. Unless new members or parts are added to the bridge the cost of maintenance will not be increased. The strengthened bridge is generally subjected to the practical test of rolling loads, as in the case of new bridges.

The extra cost of the metal in bridge strengthening works may be anything from 10 per cent higher than for ordinary works. It is often much more than 10 per cent because of the peculiarities of the site, the extra cost of Sunday labor, the extra cost of drilling and riveting in small patches, the extra care that must be taken that no part, temporarily weakened, should fail, and the precautions necessary for safeguarding the traffic, together with many unforeseen difficulties which will occur during the progress of the works.

The subject of this report is of importance and one which the railway engineer has to be continually dealing with. It is a constant source of revenue expenditure which is annually being incurred by railway administrations all over the world, and the suggestion of any ways or means by which it can be judiciously reduced without impairing the efficiency or lowering the existing standard of the track must be always welcome to those responsible for such expenditure.

In bringing this report to a close, the reporter desires to express his consciousness of the incomplete and general nature of his treatment of a large and difficult subject, pleading in his defence, the circumstances under which the report has to be compiled, and the certainty that the members of the congress who will discuss the subject more fully, will excuse and make good the deficiencies.

Docks and Wharves*

The Committee on Subject No. 10—Docks and Wharves, including Appliances for Transferring Cars from Wharves to Floating Equipment and Best Method of Transferring Freight from Dock Warehouses to Vessels, and from Vessels to Dock Warehouses at Various Stages of Water, respectfully submits the following report:

The subject of Docks and Wharves was reported on and discussed at the 1905 Convention; for that reason this part of subject No. 10 will be touched upon only in a general way by this committee.

That part of the subject relating more particularly to transferring passengers from terminal stations, and freight in packages or carload lots from wharves to vessels or vice versa, will be treated more in detail.

In order to obtain the information in regard to the practice of handling passengers and freight at various points, the committee prepared a circular letter containing a number of questions relating to this subject, and mailed them to the members of this association. The committee, however, was not very successful in obtaining data; out of 43 inquiries sent out, only seven replies were received, and of these only four contained information on the subject matter.

The report of the committee will necessarily have to be based principally upon research from engineering publications and reports of other associations.

DOCKS AND WHARVES.

These are general terms for structures located at water terminals where vessels are docked and where freight is transferred from vessels to freight sheds, railroad cars, etc., or vice versa.

The various structures comprising the docks and wharves at a terminal may be classified as follows:

Lighterage Piers:

Open deck or covered piers at which freight is loaded directly from cars to vessels, or vice versa.

Export Piers:

Covered piers with one or more floors, to which freight is unloaded and store for shipment by steamers or coast vessels.

Landing Piers:

Open decks where cars are shipped and received by means of car floats, transfer steamers, etc.

Station Piers:

Covered piers without rail connections where freight is shipped and received by car floats, house barges, etc.

Coal Piers:

Open piers where coal is transferred from cars into barges or steamers either by gravity or special lifting or conveying machinery.

Ore Piers:

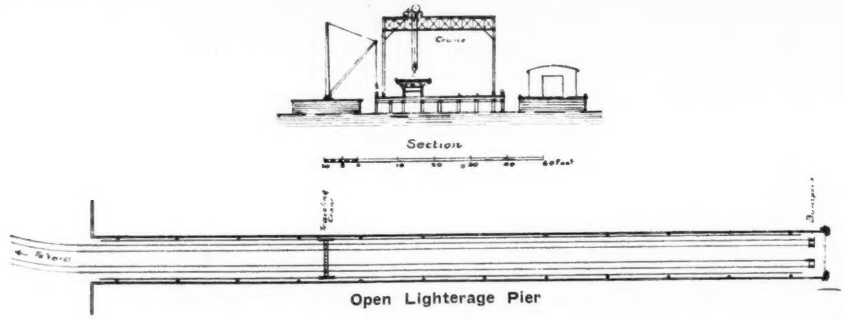
Open piers where ore is transferred from cars into vessels or vice versa.

The size of the various piers above named depends entirely on the amount and kind of business done at such piers.

For general information, the following may be of interest:

Open Deck Lighterage Piers need generally not be over 35 to 40 feet wide with two tracks along center of pier. The tracks may be depressed so as to bring the floor of cars on a level with the floor of pier on each side of the tracks. The length should preferably be from 400 to 600 feet, to give

*Report of committee of the American Railway Bridge and Building Association.



Open Lighterage Pier

ample frontage for boats to lie alongside of pier, for discharging or loading.

Covered Lighterage Piers hould generally be 110 to 125 feet wide and about 600 feet long, with two tracks in the center, the level of the tracks to be depressed so as to bring the floor of the cars on a level with the floor of the pier. There should be a platform on the outside of pier shed not less than 4 feet wide, provided with mooring piles and posts for tying vessels. The posts of the shed should be so spaced as to suit the spacing of gangways of lighters as much as possible, and the doors be arranged in such a manner as to facilitate the handling of freight. At wharves where the range of tide is not large, the sides of the piers are generally equipped with short gangway bridges that can be raised and lowered to suit small differences in the rise and fall of the water, to facilitate wheeling and transferring freight to harbor barges, etc.

The pier shed superstructure should generally be of steel construction or slow burning mill construction. If wood is used, it should be painted with fireproof paint or whitewashed to prevent sparks from setting fire to it. The outside of shed is often covered with galvanized sheet iron. The roof should be designed flat with a monitor along center of house provided with windows, to furnish as much light as possible. The shed should be lighted with electricity at night, and be thoroughly equipped with hydrants, fire plugs, automatic sprinklers and buckets, for fire protection.

Export and Storage Piers:

These should be about 125 feet wide and from 600 to 800 feet long, depending upon the class of vessels calling at the pier; they should be built for ample storage capacity. Generally two-story sheds are used for these piers on account of the height of ocean steamers, the first story about 20 ft., the second story about 18 ft., clear height, making height from top of pier to eaves about 42 ft. A platform about 6 ft. wide should be provided on the sides and water end of piers; on this platform to be placed mooring piles and posts for fastening vessels, etc. These piers should be provided with two tracks running along center of pier shed, the tracks to be depressed to bring floor of cars on a level with the floor of the pier. In some cases it is desirable to run an open track along one side of shed for unloading direct from cars to vessels, in which case the platform on the track side is to be made not less than 12 ft. wide. The pier shed should be provided with monitors and windows in the roof, and also a number of smaller windows along the upper part of sides of second story. The shed should be lighted by electricity and be provided with fire hydrants, chemical fire extinguishers, automatic sprinklers, chemical engine, buckets, etc., to give full protection against fire.

For handling freight between the two stories, when a track cannot be provided on the upper floor, a suitable number of elevators for freight and endless barrel elevators should be provided. Spiral or inclined chutes may be provided for lowering certain kinds of freight from the upper to the lower floors of pier sheds.

At piers where passengers are landed from steamers, etc., the upper floors are frequently used in part for such purposes.

Landing Piers:

These piers have rail connection with the yard tracks and generally form the bulkhead and support for transfer bridges upon which cars are transferred from the land to the floating equipment, or vice versa.

Station Piers:

These piers or freight stations are generally located along the harbor where no rail connections can be made and freight is delivered by car floats or transfer steamers and passengers by ferry boats. The size of such piers again depends largely upon the amount of business handled, and in some cases, like New York Harbor, more frequently upon the amount of room available. For freight service such station piers should be, where the room is available, from 110 to 125 ft. wide, and about 600 ft. long, providing for a driveway along the center and storage along the sides. A 3-ft. platform should be provided on the three sides of shed along the water, equipped with a proper number of mooring cleats, piles or posts, for tying car floats and other vessels. Incoming freight will be delivered to pier by car floats and cars unloaded. While the outgoing freight will be received, preferably from a bulkhead along street adjoining the water edge, where the heads of car floats can be tied to bulkhead and the freight delivered over the end of car floats on the center platforms direct to the cars on the floats; in this manner the handling of outgoing freight will not interfere with the handling and hauling of incoming freight.

For the passenger service special landing slips and bridges are provided. The ferry boats enter the slip, the hinged bridge is raised or lowered to suit the height of lower floor of ferry boats, and, after the boat has been properly secured by means of hand winches on the bridge, the passengers pass out. A small difference in height between the floor of ferry boat and the hinged bridge is generally overcome by placing small movable platforms from boat to bridge to allow foot passengers to pass without danger or difficulty. In double deck ferry boats, overhead hinged bridges are provided for landing passengers to second story of passenger shed or station.

Coal Piers:

These are generally built of such height as to admit the dumping of coal from hopper-bottom cars into pockets provided in the pier and let through chutes directly into the vessels. The chutes are arranged so that they can be raised, lowered or extended, to suit the requirements of the vessels loading coal. At coal piers usually special arrangements must be made in the chutes and pockets to reduce the drop of the coal on account of breakage. Screens are also required for hard coal chutes to clean the coal from dust. Coal piers are built with three or five tracks on the top deck. When three tracks are used the two outside tracks are used for loaded cars and the middle tracks for the empty cars. The grades and switches are generally so arranged

that the cars, when unloaded, can readily be moved to end of pier, and from there over to the center track, the grade of which descends in an opposite direction from the loaded car tracks, to drop the cars back toward the shore and general yard.

For long piers generally five tracks are used. The two tracks nearest to the edge of the pier are used for loaded cars, and coal is dumped from both tracks and delivered by chutes to vessels, while the center track is used for return of empty cars similar to the arrangement of three-track pier.

The pockets on the pier and the chutes to be so located as to suit the lengths of cars, and the crossover switches between the loaded car tracks should be so arranged that cars can readily be shifted from one track to another when desired, to bring the needed grade of coal to a certain vessel; this is especially necessary for piers where hard coal is handled, on account of the many grades of coal provided for the market.

Locations of coal piers, where a down grade can be obtained from the general yard to the top deck of the pier, and the top deck also on a downward grade with the traffic, will give the best results, as coal can be quickly delivered to the pier; where this is not possible, the arrangement of grades in the yard on approach to pier is such that the cars can readily be delivered near the end of the pier; at this point a steep incline is provided and cars are pulled to top of pier by means of steel cable and stationary engines, or the cars may be run out on lower deck to near sea end of pier and hoisted on incline to top, and then let the loaded cars drop back over pockets for unloading and returning to empty car yard. The delivery of coal for such piers is necessarily slower than for locomotive delivery where a number of cars can be delivered over the various tracks leading to pier. Another plan may be used of providing an upgrade to water end of pier, pushing the cars from the yard to outer end, and letting them drop back, on downgrade, over the pockets for unloading and returning to empty car yard, the switches being so located that the cars can be led to one or more tracks where light car trains are made up. The grades are generally such that cars are allowed to move, without requiring an attendant, to empty car yard.

Another system of coal pier in use is the so-called car dumps, where loaded cars are raised upon a steel frame and hoisting machinery by stationary engines, and dumped by the frame holding the car tilting and spilling the coal into a large chute over which the coal is delivered into vessels. The capacity of such plants is also limited on account of taking care of only one car at a time, and, in case of a breakdown in the machinery, the plant is idle, while for locomotive delivery piers interruptions on account of breakdowns are not as frequent, nor cause the stoppage of the plant, as cars can be delivered on several tracks and by the turnouts and crossovers to numerous pockets on the piers.

Coal piers, where arrangements can be made for storing a quantity of coal in the pockets of piers preparatory to loading vessels, will be of advantage.

All coal, before entering the shipping pier, is generally weighed, and a suitable track scale will have to be provided a proper distance from the entrance to pier.

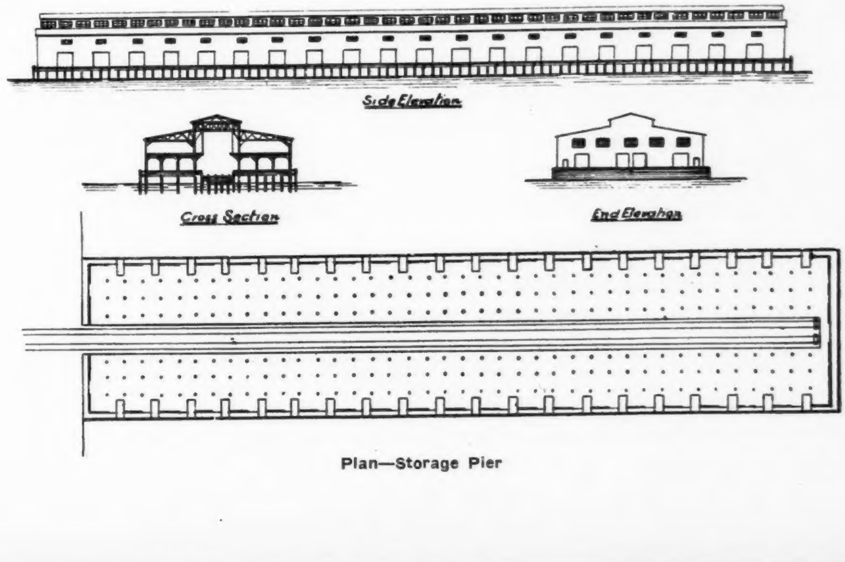
Ore Piers:

Piers for loading ore into vessels are built and used much on the same general principle as coal piers. When favorable, the cars should be delivered on top of the pier by locomotives. The piers should be made of such width and height as will take care of the kind and size of vessels to be loaded.

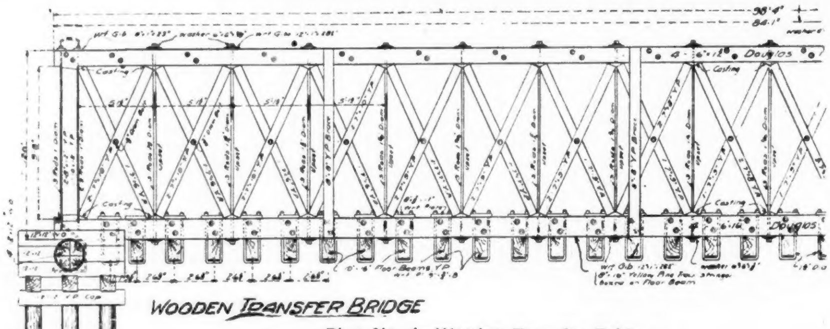
Ore piers for loading ore from vessels into cars or on stocking piles on piers are arranged quite differently from the piers for loading ore into vessels. Open deck piers are used for loading ore into cars, the vessels are tied against the pier, and the ore picked up in the boat by a grab bucket; these buckets are operated in a number of ways; the simplest and crudest method is by hoisting the bucket from the hold by a derrick and hoisting engine on the vessel, and then by the so-called telpherage method moved to the pier with a rope operated by a hoisting engine on the pier. Numerous hoisting engines and derrick poles are provided along the dock to admit working from the various hatches in the vessel. Another more modern method is to provide on the pier an electrically operated hoist or hoists mounted on a steel frame with long arms reaching from the pier to the center of the vessel; these hoists are movable on a track parallel to the pier, the buckets are lowered into the vessel from the long arms, and, when loaded, are raised to the proper height to clear cars, and then moved on the arm by means of a small trolley toward the car, and the ore dropped into the cars standing on a track between the edge of the pier and the side of the hoist. For storing ore on piers or ground back of piers generally long armed traveling hoists are used, reaching from the boat beyond the pier, the ore is picked up by grab buckets, raised to proper height, and then moved along the arm of the hoist to point of storage. These hoists are also mounted on tracks and can be moved parallel to the pier.

The long arm hoists can also be used for loading ore from the vessel direct into cars or from the storage dump into cars standing adjacent and parallel to pier.

The foregoing description of the various piers will give



Plan—Storage Pier



Plan No. 1—Wooden Transfer Bridge

a general idea on the subject of docks and wharves, and, while in some instances the subject of handling freight, etc., had to be touched upon to give a clear description of a certain pier, this subject will be treated in detail in the following paragraphs.

Appliances for Transferring Passengers and Freight from Wharves to Floating Equipment:

a. Transferring passengers in cars to floating equipment and vice versa.

b. Transferring passengers from wharf stations to floating equipment and vice versa.

c. Transferring freight in cars to floating equipment.

d. Transferring package freight from pier freight sheds and warehouses to floating equipment or vessels.

e. Transferring package freight from floating equipment or vessels to piers, freight sheds and warehouses.

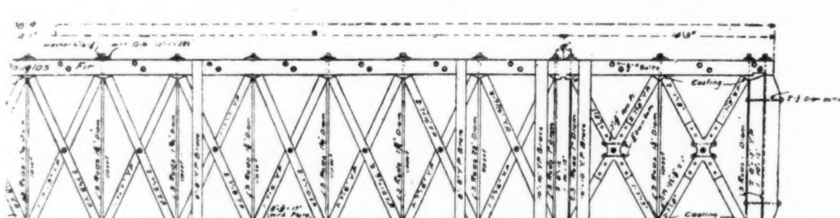
Passengers in cars are transferred over transfer bridges to a car float or transfer steamer, moored to the transfer bridge.

The transfer bridge is either a wooden or steel girder or truss bridge, hinged at the shore end or bulkhaed so as to allow a vertical movement of the bridge. The outer end of the bridge is generally supported on a pontoon which rises and falls with the tide or variation in level of water. The pontoons are generally provided with a pump to facilitate raising and lowering of bridge. The modern transfer bridges, especially where passenger equipment is handled, are hinged at the shore or bulkhead end similar to the above mentioned pontoon bridge, but the outer end is supported by steel bars and heavy screws from an overhead steel frame and girders. These modern transfer bridges are usually built with an apron or second span to allow a larger vertical movement, and to produce easier grades for the motive power to be moved over it. The shore end of the transfer bridges being fixed on a pin bearing, even for moderate differences between high and low tides or water, junctions of grades are produced that must be regulated to the maximum vertical movement provided for in the cars, so as not to uplift them from their bearings or otherwise injure them. The general styles of the single span transfer bridges usually employed for handling freight traffic are shown by Plan No. 1, and those of two spans generally used for passenger cars are shown by Plan No. 2 attached.

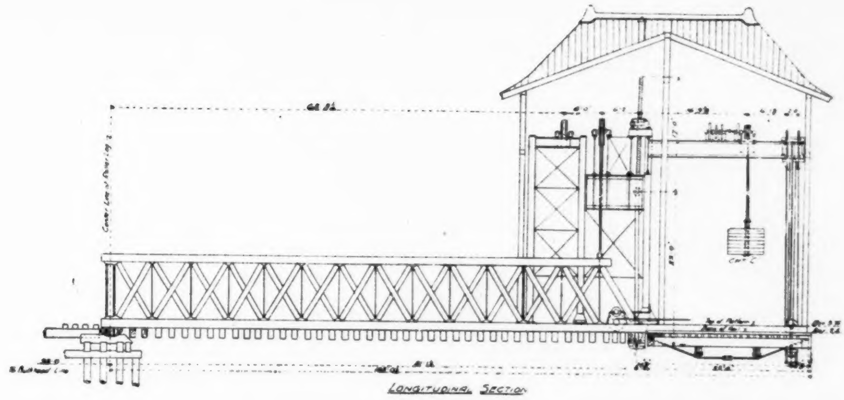
The Intercolonial Railway Co. have in service at Mulgrave, Nova Scotia, and Point Tupper at Cape Breton, a three-leaf or three-span transfer bridge to serve steel transfer steamers carrying both freight and passenger traffic across the Straits of Canso. The shore span is a through truss 100 ft. long, the middle span girders 50 ft. long, and the outer or sea end span girders 35 ft. between supports; the latter is provided with a 15-ft. overhang over supports to allow the transfer steamer to reach under the bridge while being loaded.

A very complete description and photographic views of the transfer bridges of the Intercolonial Railway at Mulgrave, Nova Scotia, and Point Tupper at Cape Breton, and the transfer steamer Scotia, has been furnished by Mr. John Forbes, bridge engineer of the Intercolonial Railway, and is given in full in the Appendix.

The floating equipment for transferring passengers in cars generally consists of steel ferry or transfer steamers on the deck of which are laid two or three tracks, as the traffic may require; these tracks usually converge to two tracks at the ends, to fit the tracks on the transfer bridge, the transfer steamer is brought up against the end of the transfer bridge, and by means of toggle bars a connection is made between transfer bridge and transfer float or steamer, bringing the level of rails on one plane. To hold the transfer float or steamer in position against side motion, guard racks or fenders are provided forming a berth for the transfer vessel; to this rack or fender, as well as to the transfer bridge, the float or steamer is securely fastened or moored before any



Plan No 1.



Plan No. 2

loading or unloading is done. The work of loading or unloading must be done carefully, to balance, as much as possible, the weight on the boat, to avoid excessive twists on toggle bars and transfer bridges by the listing of uneven loads or transfer floats or steamers. Special provision should be made in the construction of the outer leaf of transfer bridge to allow the twisting or warping of the bridge to suit the list in the boat.

Transferring Passengers from Wharf Station to Ferry Boats or Steamers:

The ferry boat enters the slip or berth provided for landing and is brought against the generally short wooden transfer bridge. The ferry boat is then moored to the transfer bridge. The bridge is raised or lowered by means of hand winches mounted one on each side of the transfer bridge, and, when the proper level between boat and bridge floors has been established, small platforms are thrown over the gap or joint between the boat and the transfer bridge, and the passengers pass afoot from the ferry boat over the transfer bridge to destination. The teams, automobiles and other vehicles, are generally provided for in the central portion of the ferry boat, and move off the boat simultaneously with the passengers, separate passageways being provided for passengers on each side of the driveway. Where double-deck ferry boats are used, auxiliary narrow steel transfer bridges with short wooden aprons are provided for receiving and discharging passengers from the upper deck to second floor in dock house or station.

The ferry boats are usually double ended to avoid turning; they are about from 160 to 200 ft. long and from 50 to 60 ft. wide, either single or double decks. The lower deck is divided into three parts, the central parts for teams and other vehicles, and the two outside parts for passengers. The upper deck generally forms one passenger compartment. The modern ferry boats are operated by means of screws, while some of the boats of older construction are operated by side paddle wheels.

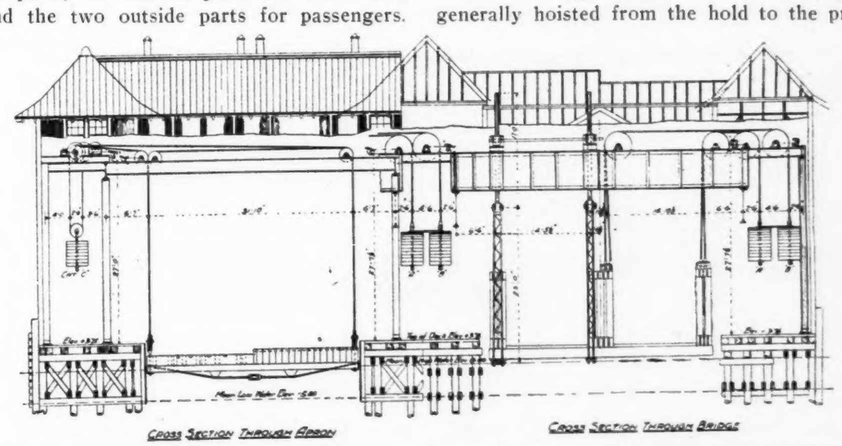
Transferring Freight in Cars to Floating Equipment or vice versa:

For transferring freight in cars to floating equipment similar methods are employed as for passenger car transfer, except that for freight purposes generally car floats without power are used; these car floats have usually two tracks converging at ends to suit the spacing of the tracks on the transfer bridges. The car floats are toggled to the transfer bridges and properly moored, then the cars are run over the transfer bridges onto the car floats, taking care to keep the load on the float balanced as much as possible. When the float is loaded, or has all the freight that must be handled to a certain delivery point, the toggle bars are pulled back to the transfer bridge, and the float loosened from its moorings and moved by a steam tug boat. The transfer bridges used are the same as for the passenger car transfer already described.

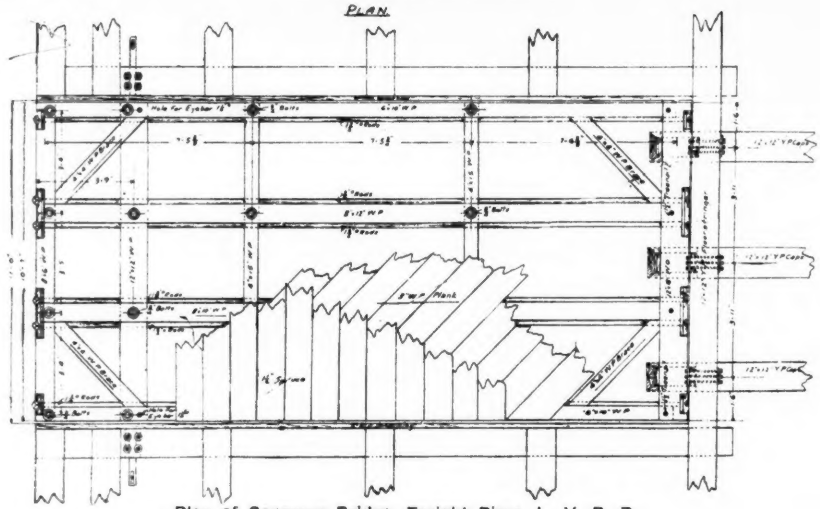
Transferring Package Freight and General Merchandise from Boats to Freight Sheds and Warehouses:

For the flat-top or covered harbor barges or boats, the smaller package freight is generally wheeled on trucks over small platforms, resting on the edge of the pier and on the vessel to the freight shed or warehouses. The larger and heavier freight is hoisted by means of derricks located either directly on the vessel, or on the edge of the pier, and from there trucked or rolled to the warehouse, where it may be loaded on delivery wagons by means of a hoisting crane.

For the larger vessels or steamers, package freight is generally hoisted from the hold to the proper deck on the



Plan No. 2—General Plan of Transfer Bridge with Outer End Suspended from Overhead Truss



Plan of Gangway Bridge, Freight Piers, L. V. R. R.

vessel, and then discharged to the pier either by sliding over a chute from the vessel to the edge of the pier, or by a derrick on the edge of the pier taken from the deck of the boat and lowered or carried to the pier, and from there either trucked or rolled into the warehouse for storage or for loading on delivery wagons, as the case may be.

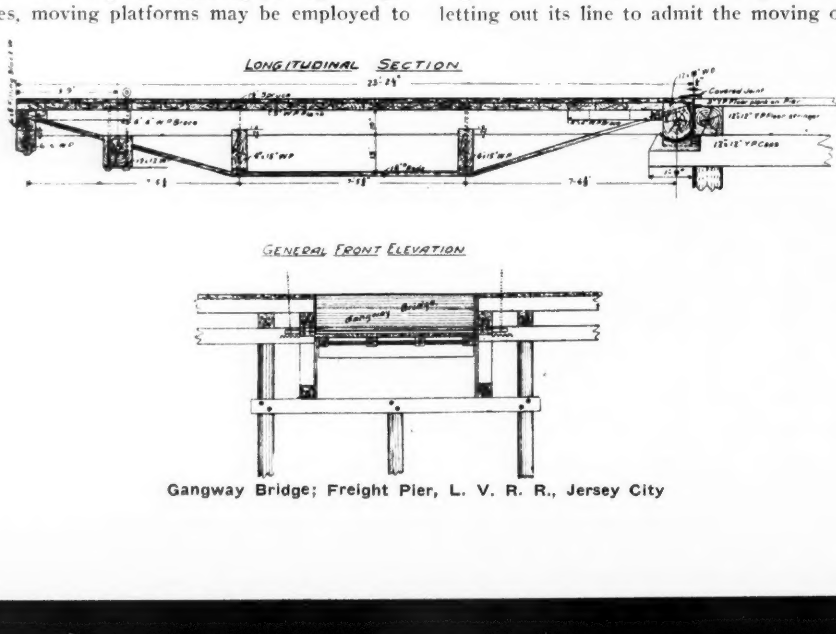
Package freight that requires rail transportation may also be transferred from the boat or vessel direct to freight cars standing on car floats on the opposite side of the pier shed, or as may suit the facilities provided.

Transferring Package Freight from Pier Freight Sheds and Warehouses to Floating Equipment:

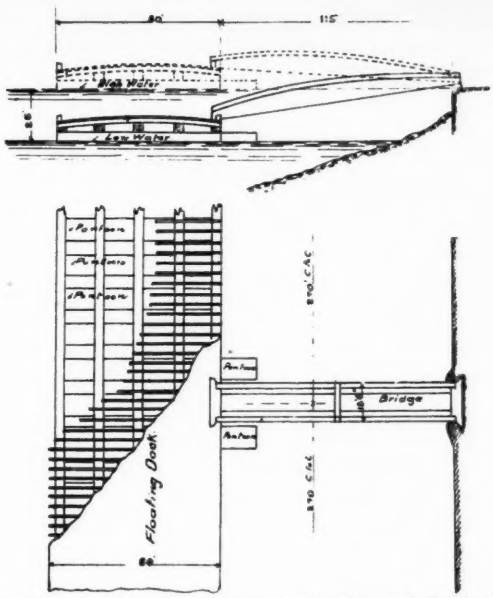
For the flat top barges and the roofed barges generally used for harbor business, the lighter pieces of freight are generally wheeled to the boat by hand trucks, the heavier pieces are lifted from the edge of the pier shed or warehouse to the boats by steam, or electric power derricks, or for special cases derrick-equipped boats are brought to the pier shed, etc., to take the freight from the pier to the boat; this latter has the advantage in discharging the freight from the boat to warehouse where no derricks or lifts are provided.

For handling package freight and general merchandise, especially when certain freight of uniform packages is frequently handled, power conveyors may be employed in the warehouses between the second floor and the dock floor, such as elevators, automatic barrel elevators, spiral or inclined chutes. For delivering and handling package freight in long warehouses, moving platforms may be employed to good advantage in place of the usual trucking; in such cases, the inclined or spiral chutes from the second story should be so arranged that the freight lands on the moving platform and is carried to a point directly opposite the boat or vessel to be loaded, and there dropped automatically from the moving platform and then transferred in the usual manner to the vessel. For large vessels, the top deck of which reaches considerably above the lower floor of the warehouses, freight from the first floor of the warehouse can be raised to the boat by means of stationary or movable derricks located on the edge of the pier shed, or by means of derricks located on the vessel to be loaded. From the second story the smaller package freight can generally be slid down on an inclined chute to the deck of the vessel, unless the boat is very large, in which case the freight is hoisted to the boat with derricks; movable narrow inclined moving platforms or conveyors leaning against the boat or vessel for handling smaller package freight may be employed.

For transferring ore or freight of similar character, special unloading machinery is provided, such as traveling hoists, cranes, or the more crude arrangement known as the telpherage system, using a derrick on the vessel to lower and raise the bucket to and from the hold of the vessel, and when above the level of the deck attach a rope to the bucket, operated by a hoisting engine over a mast, both located on the pier, pulling the bucket over to the pier, the derrick engine on the boat still having hold of the bucket but letting out its line to admit the moving of the bucket to the



Gangway Bridge; Freight Pier, L. V. R. R., Jersey City



Landing Arrangement for Passengers, Liverpool, England

pier for dumping; this operation is reversed and repeated for every bucket load. Both the vessels and the pier are equipped with a number of hoisting engines, derricks and masts for working on several hatches to facilitate quick unloading.

The traveling hoists or cranes are provided with arms extending over the center of the boat or vessel; on these arms automatic grab buckets are operated; these buckets are let down into the hold of the vessel to grab a load of ore, etc., then they are hoisted to the level of the top of open cars and run along the extended arm to shore, and dumped into the cars which stand on a track running along the dock, between the edge of the pier and the traveling hoist or crane. The cars when loaded, and empty cars for loading, are generally moved along the pier track by means of a cable and winches operated by small engines located on the pier.

At points where ore, etc., is received in larger quantities that can be loaded on cars at once, or on the great lakes where navigation stops during the winter months, and a winter supply of ore, etc., is delivered, long arm traveling cranes are provided, and the ore that is not to be loaded on cars for immediate transportation is stored on the so-called ore storage docks, the buckets taking the ore from the vessels are then traveling overhead beyond the loading tracks, and discharge the ore, etc., on storage piles, from where, when the material is required for shipping, it is again picked up by buckets operated from the crane and loaded into cars for shipment.

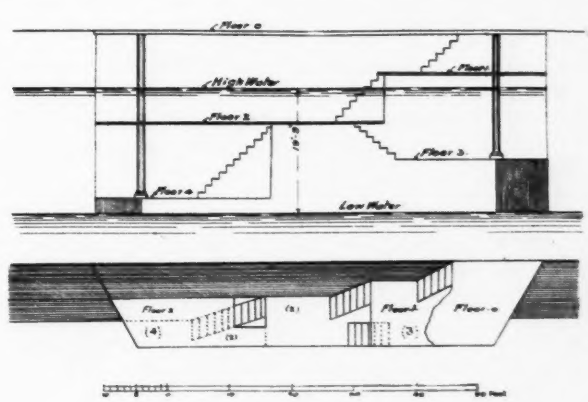
The committee has been unable to obtain much data relative to handling of freight in cars and package freight at points where the range of tide is very large, as compared with the range of tide at New York Harbor and vicinity.

The following are some of the maximum ranges of tides at various seaports, harbors, etc., on the North American Continent, as recorded in the Tide Tables issued by the United States Department of Commerce and Labor, Coast and Geodetic Survey for the year 1908.

New York, the Battery	5.3 ft.
Hudson Bay, Port Churchill	15.5 ft.
Hudson Strait, Ungara Bay	38.5 ft.
Labrador Indian Harbor	7.0 ft.
Newfoundland East Coast	7.0 ft.
St. Lawrence River, Murray Bay	17.0 ft.
Quebec Dry Dock	14.9 ft.
Bay of Fundy, Digby Pier	27.5 ft.
Bay of Fundy, Port George	32.0 ft.
Bay of Fundy, Noel Bay Minas Basin	50.5 ft.
Bay of Fundy, Moncton Railway	47.0 ft.
Bar Harbor	11.8 ft.
Portsmouth, N. H	10.5 ft.
Boston Light	10.9 ft.
Buzzard Bay, Kettle Cove	5.3 ft.
East River, Hell Gate Ferry	6.2 ft.
Oyster Bay	8.5 ft.
Sandy Hook	5.6 ft.
Cape May Light	5.5 ft.
Norfolk Navy Yard	3.2 ft.
Old Point Comfort	3.0 ft.
Savannah, Tybee Light	8.0 ft.
Miami Key-Biscayne Bay	1.3 ft.
Key West, Fort Taylor	1.6 ft.

Moderate ranges in the tides, up to 10 ft., can be taken care of by means of the transfer bridges for transferring freight on cars to floating equipment, but for the greater ranges of tide or water the freight is either held for favorable height of water to transfer cars over transfer bridges, or arrangements made on the piers for several heights of delivery tracks; in such cases the transfer bridges have to be longer than usual and be suspended from overhead girders and frames counterweighted, etc., thereby providing for a larger range. Another method would be to have the transfer bridge suspended entirely and arranged to move up or down, providing for several heights of track on the transfer bridge and also in the pier carrying the tracks leading to the transfer bridge, or providing more than one transfer bridge for different heights of water. At points where only a moderate amount of freight is handled in cars, it may be held until the tide has reached a favorable level for the transfer of cars over transfer bridges, the track level of which should be a reasonable distance below the high tide, as high tide generally does not last long enough to make the transfer.

At the Glasgow Harbor, Scotland, the Clyde Trust has in service the Elevating Ferry Steamer "Finnieston," 104 ft. long and 45 ft. wide; it is provided with a movable track platform on which cars are transferred, the platform is raised or lowered by eight double-threaded buttress screws of forged steel, and the screws are hung on collar bearings in cast steel brackets which are supported by the frame posts. The platform is built of steel girders, closely spaced, connected at ends by massive steel girders on each side of the vessel. A triple expansion engine is used for operating the elevating platform. The platform is constructed for a range



Arrangement for Landing Passengers, Dover, England.

of 17 ft. in height. The maximum range of tide at Glasgow Harbor is 11.2 ft.

For the handling of package freight at piers where the larger ranges of tide are to be met, drop stages 30 ft. long are used at one of the New England piers; these drop stages are hinged at inner end and carried by a gallows frame at outer end; counterweights are arranged on this frame so that the stage is raised or lowered by hand. Movable brows are used to connect the outload of drop stage with the deck. Some of the drop stages above mentioned have been equipped with electric escalators; these are so made that a man and truck ride up the moving gangway without effort and proceed on the floors of the pier shed when the top of the escalator is reached. The movement of these escalators can be reversed if desired to use them for taking freight into the vessel. The stages are wide enough to allow ample gangway alongside the moving escalator.

At some European ports the ranges of tide are large, for instance:

Thames River, London	20.5 ft.
Liverpool	25.0 ft.
Cherbourg	17.6 ft.
Southhampton	12.8 ft.
Havre	22.5 ft.
Cardiff	36.2 ft.

The docks are generally built in such a manner that the vessels are sheltered against large ranges of tide; these wharf systems are usually provided with a mean water and high water basin; the mean water basin, at entrance to wharves, is provided with sluice gates, these sluice gates are kept open during the time the tide is above mean water, this gives the vessels about six hours to enter the harbor. As soon as the tide reaches the level of mean water the sluice gates are closed and the water in the lower basin held at mean water level. The water in the high water basin, or basin where the vessels are docked, is generally held at the level of high tide by means of sluice locks located between the mean water basin and high water basin. High tide, as a rule, does not last long enough for vessels to pass from the low water basin during high tide; for that reason regular locks are provided between the two basins for transferring the vessels from low to high water basin. The vessels are docked in the high water basin, and discharge and take on cargo without being influenced by the tide, the water being held at a uniform level.

For loading and discharging passengers from the side of the vessels, floating stages or platforms are used at Westminster, London, England; these floating platforms, 240 ft. long, 40 ft. wide, are supported by 19 pontoons and connected with the shore by two transfer bridges 90 ft. long and 7 ft. wide. At Liverpool a floating dock is provided 1,950 ft. long, 80 ft. wide supported by 112 pontoons and connected with shore by seven transfer bridges 115 ft. long and 18½ ft. wide. At Dover, England, different heights of platforms are provided on the side of the pier or bulkhead; the level of these platforms are reached by means of 8 ft. wide stairways. The passengers can be landed without difficulty at various levels of water. The range of tide at this point is 19 ft. 9 ins.

The European idea of handling freight at wharves where a large amount of package freight of all classes is handled, is to provide either a number of fixed swinging derricks along the edge of the pier to take freight from vessels to pier shed or vice versa, or one or more movable derricks operating along the water edge between the pier shed and the vessels; such fixed or moving derricks to be operated either by steam or electricity. The prompt and quick handling of freight from and to vessels is of the greatest importance and the success of the system of docks and wharves depends upon the proper kind and number of mechanical devices provided, and not too much attention can be given to the developing of machinery and apparatus for the more economical and prompt handling of freight on piers and from and to vessels.

Water Supply*

There is perhaps no problem in connection with the operation of a railroad of greater importance than that which pertains to its water supply. The problem pertaining to an individual station may be a simple one, while in others many serious difficulties may be encountered, depending mainly upon local conditions, the quality of the water being also taken into consideration.

The road which traverses a locality abounding with a good quality of water does not have to resort to drilling wells of a great depth, and then operating them at heavy expense or perhaps piping or hauling water for many miles.

Lakes and streams naturally furnish the best quality of water for boiler use, unless it contains organic matter, which if in excess causes it to foam; such impurities can not well be removed by any practical process.

Shallow wells furnish the next best supply, and the last resort that furnished from deep wells; the latter as a general rule is more difficult to obtain and of poorer quality for boiler use.

Water purification has been quite elaborately touched upon in our Thirteenth Proceedings; hence it will not be considered at this time, suffice it to say that many roads are giving the matter considerable attention where the quality of the water can be improved.

When the source of supply has been determined the important question arises as to the best style of plant to be used for pumping and delivery. There is no doubt but that many roads fail at first to get a practical and economical system, for no other reason than that it may not be given due consideration by those best capable of judging which is the best apparatus to use for each specific case. It often happens that the practical man is not consulted at the time when the plant is designed and constructed, but he is often called upon later to remodel it or re-arrange it in such a manner as to make it do what is required, and to operate and maintain it at the minimum cost.

Pumping machinery and water supply material should be standardized as much as can be, for obvious reasons; it is not wise to have a great variety of apparatus doing like service on one division of a road, or in the same locality; this should apply not only to pumps, but windmills, tanks, tank fixtures, stand pipes and the like.

The subject of water supply in general has been given extensive consideration by the American Railway Engineering and Maintenance of Way Association in its 1909 Proceedings; most of our members can gain access to these Proceedings and will do well to look them over carefully; sufficient data is given which should enable one to determine the relative merits for steam as compared with gasoline for the operation of a plant under certain conditions.

As a general rule, where a well is located within a reasonable distance from an existing steam plant, as at division headquarters, it is more economical to use steam for pumping than gasoline.

One phase of the subject which has been given little attention in the past, and well worthy of investigation and consideration is that of operating pumps by the use of motors, especially where the supply of water is easily obtained, and where the pumps must of necessity be located at some distance from the power plant.

This subject is too broad to be considered in its entirety

*Report of committee of American Railway Bridge and Building Association.

in one report, and the committee would recommend that hereafter it be considered by subdivisions, as more thorough work can be accomplished by giving more attention to details; committees should be selected from the same localities in order that they can get together periodically and work in a systematic manner. By doing this, much useful data may be collected and compiled.

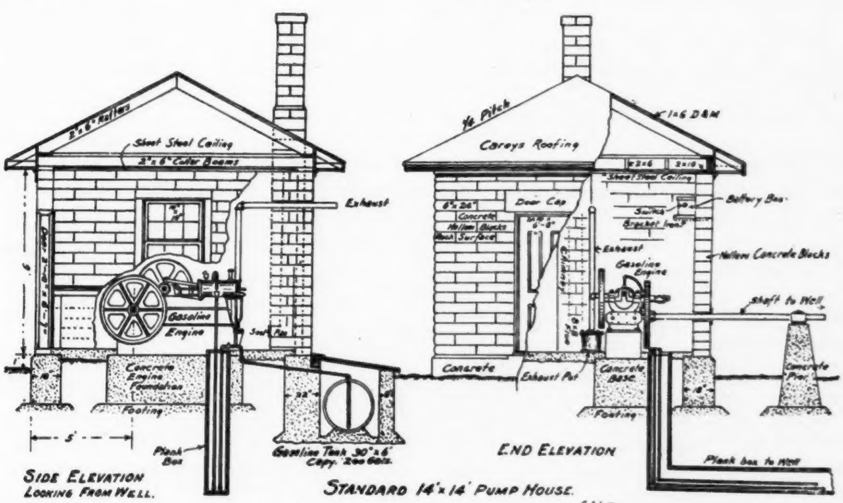
LIST OF QUESTIONS.

1. What is the most economical method of pumping water from dug or shallow wells?
2. What is the best method of pumping from deep wells?
3. Give comparative cost of pumping by the use of steam and gasoline, and by the air lift process.
4. What kind of foundation do you use in setting gasoline engines?
5. Do you set gasoline engine over well, on one side of it, or some distance away?
6. What material do you consider best for pump house walls; concrete blocks or lumber?
7. Where water is poor, such as is found in North Dakota, do you think it advisable to use steam for power in pumping?
8. Are you using purifying plants; if so, with what results?
9. Have you experienced trouble with freezing of stand pipe?
10. What kind of stand pipes do you consider to be the best?
11. What makes and sizes of stand pipes do you use?
12. How deep do you make the pits for stand pipes or water columns?
13. What kind of tank valve do you use, and what experience as to leaking?
14. Do you experience any trouble from outlet spouts freezing?
15. Do you use extension of inlet pipe above floor in tank?
16. What size of tank and kind of wood?
17. Any trouble from pipes freezing in frost proof box?
18. Please send drawing showing construction of tank and frost proofing.
19. What kind of tank foundation, and how constructed?
20. What make of windmill and size of wheel?
21. Make and size of pump for windmills?
22. Have you experienced difficulty from the operation of long discharge pipes?
23. Length and size of suction pipes.
24. Do you use rams? If so, name size and capacity, and kind of service rendered.

ANSWERS.

A. H. Hogeland, Chief Engineer, Great Northern Ry.:

1. All of our pumping is done with gasoline engines or windmills, except at some terminal points where either electric or steam power is used.
2. We pump from deep wells with gasoline engines.
3. We have never used air lift for pumping. We discontinued the use of steam pumps for pumping water some years ago, since which time we have used gasoline engines almost entirely, having found the same much more economical than steam.
4. We use both timber and concrete foundations, with a capstone, depending on conditions. If we are reasonably sure that the location will be permanent we usually use concrete.
5. In no case do we place the engine directly over the well. Where we use a geared base engine the same is placed partly over the well and supported on I beams. We do, however, when it is necessary to use a pump jack, place the pump jack directly over the well, supported either on I beams or timber.
6. Most of our pump houses are built of lumber. We have some fireproof pump houses, however, which are built of brick, with concrete roof.
7. The same answer as to question No. 3.
8. No. We have been able, so far, to overcome the difficulty of using very bad water by installing reservoirs dug into the natural ground, of a capacity of twenty or more million gallons, in which to store water collected from spring floods and melting snow.
9. No.
10. Same answer as to question No. 11.
11. We use Johnson, also Sheffield, 10-inch stand pipes.
12. Depends on climatic conditions.
13. We use our own design, which is practically the same as Fairbanks, Morse and Company's valve. We have not experienced any particular trouble on account of valve leaking and wasting water.
14. Yes, in extreme weather.
15. Only a slight extension.
16. We use 48,000 gallon tanks 16x24 feet and 100,000 gallon tanks 20x30 feet. Cedar and white pine staves and bottom.
17. Yes, occasionally in extreme weather.
18. Drawing furnished.
19. Depends on conditions. If the natural ground surface is good we use footing stones; if there is any question, however, as to that, or if on newly filled ground, we use concrete piers.



Concrete Block Pumphouse, M., St. P. & S. S. M. Ry.

20. Eclipse, 20 feet.

21. Curtis, also Eclipse, double acting pumps. Different sizes, depending on the amount of water required—3x12, 4x12, 5x16, 5x18, 6x18 and 8x24.

22. We have discharge pipes varying in length from a few feet up to six miles, and in size from four to ten inches. We have had no particular trouble with these long discharge lines, providing the placing of them was well done and they were operated under proper conditions.

23. We have no long suction pipes, it being the practice to avoid them, as it has been found that they are not satisfactory. The size of suction pipe depends upon conditions as to the amount of water, etc., required. It has become, in late years, the almost universal practice not to use smaller suction line than 6-inch.

24. No.

C. E. Thomas, General Foreman of Water Works, Illinois Central R. R.:

1. Taking everything into consideration it is the cheapest proposition to pump water from a dug, or shallow well, by means of gasoline as a power.

2. The most economical way of pumping water from deep wells, as far as the experience of this company is concerned is either by use of steam head or air, providing the water is not drafted down at too great a depth, in which case it is not an economical way to lift water by air.

3. With us it is difficult to show any advantage of the gasoline supply to the steam or air lift, for the reason that the coal which we use at our pumping stations is obtained at a very low figure, being a cheap grade which is not used in manufacturing plants to any great extent.

4. We use concrete or brick for putting in foundations for gasoline engines.

5. Generally speaking, we put gasoline engines directly over wells, connected to a pump head or a double-acting pump, located twelve to fourteen feet below engine.

6. We do not use anything but lumber in construction of our pump houses, but it is my opinion that concrete blocks or brick would be a decided improvement owing to the fact that it would practically eliminate the fire risk and in cold climates would greatly aid in keeping pump houses warm.

7. We do not operate in North Dakota.

8. We have ten treating plants in service and are getting very good results from them, having materially reduced engine failures as well as overtime paid trainmen and wages in labor paid boiler makers. We have shown a decrease of practically 90 per cent in engine failures since installation of treating plants.

9. We have no trouble in stand pipes freezing up.

10. On main line we use 12-inch stand pipes entirely, and in yards and around shops 8 and 10-inch.

11. We consider the stand pipe with drop spout the best for all purposes.

12. The standpipe pits are put in to a depth of 6 feet 6 inches with exception of those south of the Ohio River, we put in only of sufficient depth to protect the valves and working parts.

13. Our tank valve is known as the Illinois Central standard.

14. We have no trouble with outlet spouts freezing, providing the tank valves close tight.

15. We have no extensions inside of tank above top of floor.

16. We use, on branch lines where there is no probability of any heavy increase in business, a 16x24 tank, but on our main lines we use a 20x30 tank on a stel sub-structure, bottom of tank being twenty feet above ground.

17. We do not have any trouble with pipes freezing inside of frost proofiing of tanks.

18. For frost boxes in Iowa and Illinois, we use ⅞-inch matched material, with three one-inch air spaces, each air space being properly lined with tar felt.

19. We use Louisiana swamp cypress in construction of all water tanks.

20. A 16-foot air motor.

21. 5x16-inch double-acting pump.

22. We have several discharge lines, three to four miles in length, and experience no trouble whatever in maintaining them. Our pipe lines of two miles or over are 8-inch diameter.

23. The longest suction line we have is 800 ft. and 8-in. in diameter.

24. We do not use rams of any kind.

Ed. Gagnon, Supervisor B. & B. Minneapolis & St. Louis R. R.

1. Windmill and double-acting pump 5x18 inches. If conditions for windmill are unfavorable, then use gasoline engine. A combination of the two will under certain conditions make an economical plant. In either case use a 5x18 inch double-acting pump.

2. Use gasoline engine for power, with good and reasonable power to spare over and above that actually required. Deep well pump 5¾x24 inches being perhaps the most economical.

3. We use gasoline engines principally. Steam is used at division points where a shop facilities are maintained and fire protection is necessary, requiring a high pressure at all times. In such cases the steam plants are unquestionably the most economical, steam being required for operation of mechanical devices anyway, and large quantities of water are used for various purposes, outside of that which is needed for locomotives.

Lifting water by air is probably the most costly method of supply, but may be used to advantage in case of several wells which are to be operated from one plant and where the distance water has to be raised is not too great. The saving in the operation and maintenance of pumps may offset to some extent the cost of air. We have three plants where we use compressed air to lift water. These are all located in South Dakota, where conditions are such that we were compelled to use it. An extreme case is where we bring the water up 650 feet through a three-inch pipe at the rate of forty gallons per minute, and every fifty gallons of water contains a quart of sand. As we have no other facilities at these points we get power from 40 h. p. gasoline engines in two cases, and in the third we use a 25 h. p. gasoline engine. These plants are costly to install and expensive to operate and maintain.

4. Concrete foundations are used for all gasoline engines.

5. The pump house is located directly over the well and the gasoline engine just enough to one side to bring pump-pole and overhead connections in line, so as to maintain a direct pull on rods to prevent cutting of guides and packing. The engine is set on foundation 18 inches above the floor so as to clear the gear wheel; manhole in roof provides for pulling of pipe when necessary.

6. For pumphouse walls, I consider hollow concrete blocks preferable, but we use mostly wooden buildings.

7. Unable to answer.

8. We have not established any purifying plants on this system.

9. Have no trouble with stand pipes freezing up. Where water is supplied from lakes and streams it cannot of course always be prevented from freezing, but from deep wells there should be no trouble.

10. Our adopted standard stand pipe is Sheffield No. 8, ten-inch.

11. We use Sheffield 10-inch, and Poage 8-inch.

12. Stnad pipe pits are constructed seven feet deep and covered with double floors.

13. We use 10-inch Eclipse tank valve and experience no trouble account of leaking. I consider there should exist no reason for a tank valve leaking if properly cared for.

14. In the northwest it is almost impossible not to have some trouble occasionally with outlet spouts freezing, more especially where the water is obtained from or near the surface and where only a few trains take water. Our locomotives are supplied with steam hose during the winter months and it only takes about five minutes to thaw outlet out if frozen.

15. We do not usually provide for an extension above floor inside of tank, but in the artesian basin in South Dakota we have some tanks with extensions inside, account of flowing wells carrying sand with the water.

16. Our standard tanks are cypress, 24 feet in diameter, staves 3 inches x 16 feet.

17. We experience no trouble with frozen pipes inside of frost boxes.

18. Frost box must be carefully and well made, all joints well covered, including both top and base.

19. Present day tank foundation consists of the required number of concrete pedestals, 14 inches square on top, 4 feet x 4 feet at bottom and 4 feet high. (The depth of course will vary some, according to the soil.)

20. We use Eclipse windmill with 20-foot wheel.

21. The pump used in connection with our windmills is the Eclipse 5x18 inches double acting.

22. We have no discharge pipes exceeding one-quarter of mile in length. We have one of that length which is 6 inches diameter, and it works satsifactorily.

23. We have no suction pipes of abnormal length.

24. Have no experience with rams.

In addition to reply to question 13, in regard to trouble with leaky valves I wish to state that in my opinion there is no excuse for them, if the pump man knows his business. There is a secret about this valve matter: First, valve should be put in right; holes for bolts to fasten valve to tank floor should be made 1-16 in. smaller (in lumber) than the bolt so it will drive tight and prevent leaking. Second, all bolts, pertaining to valve lever, should be made of brass, with a brass split through nut and bolt. The brass bolt costs a little more than iron, but they can be kept in good condition for ten or twelve years, according to my experience. Lever should have at least 1-16 inch play in all connections, so it will seat with perfect freedom. The valve rod should be arranged with brass bolts also; valve rod should be made with 1¼-inch gas pipe with solid jaws at both ends to fasten to valve lever to seat properly and the rod should always be set plumb. As to the lead seat, after it is worn out, I have it replaced with brass; this never wears out and is put on with pressure tight enough so it will not leak and it cannot be sprung or split with small articles which get into the valve. I always see that tank valve rubber is clamped tight so it will hold; sometimes when they are loose they will draw out with the suction when closing valve, account of the rubber being too small for the groove. In this case, set a rubber gasket over it to fit the washer plate, then bring down the set screw good and hard; this makes the relief washer valve grip tight so it cannot slip out.

We have sixty water tanks, and not one valve that is leaking. When I go over the line and find one leaking, which is very seldom, I get after the water man and get full particulars as to the cause; furthermore I do not allow chips, shavings, etc., to be left in the cornice of tank when built, as sometimes the tank may overflow and these chips will float out and be the cause of trouble. A water tank should be kept clean, and we have to go into them occasionally to see that they are clean. If these rules are carried out, there will be no trouble account of leaky tank valves.

P. Swenson, Supt. B. & B. Minneapolis, St. Paul & Sault Ste. Marie Ry.

1. Combination of windmill and gasoline engine is the most economical, except at terminals where steam power is used for various purposes by the mechanical department.

2. Use of gasoline engine connected to a displacement plunger, deep well packing head and guided cross head.

3. We use gasoline engines. We have found them more economical than steam in repairs, fuel maintenance and fire protection.

4. Concrete foundation.

5. We put pump house and gasoline engine 16 feet from the well; in so doing we can place gasoline engine on concrete foundation, and if we wish to make repairs to the well or sink it deeper, it can be done without disturbing the gasoline engine or pump house.

6. We use hollow concrete blocks and brick; they keep pump house warm and eliminate the fire risk.

7. Gasoline engine is the most economical; if steam is used, bad water causes the flues to leak in a very short time.

8. We have two purifying plants, and find them efficacious; they are expensive to install, but pay for themselves in a few years, by preventing leaky boilers.

9. Have no trouble in stand pipes freezing up.

10. We use Sheffield 10-inch improved direct acting automatic stand pipe with rigid spout fitted with anti-splashing nozzle.

11. There are several very good stand pipes on the market.

12. From 6 feet to 9 feet deep, built of concrete complete, including top.

13. Fairbanks, Morse & Co.

14. Have no trouble with spout freezing up.

15. Use 12-inch extension above floor inside of tank.

16. We use 16x24 foot tank with white pine staves.

17. No trouble with pipe freezing up inside of frost proofing of tank.

18. Of lumber and tarred paper, with air spaces between layers.

19. Concrete foundation.

20. (Blank).

21. Use 4x12 and 5x18 Eclipse double acting pumps.

22. We have several discharge pipe lines, from one-half to a mile long; have no trouble with them.

23. We have one 6-inch suction pipe 600 feet long, giving good satisfaction.

24. We do not use rams.

Track and Bridges*

1—(a) The relative unit prices of rail, ties, ballast and labor, vary so greatly at different times and places, that the determination of the economic order of strengthening of roadway by resorting to heavier rail, closer tie spacing, greater depth of ballast, or by draining the subgrade, must be left to special individual determination.

(b) The extent to which the present standard American track can be strengthened by a combination of these items is so great in proportion to the probable increased requirements of higher speed in the near future, as to make improbable the immediate need for a radical change in the type of roadway construction.

(c) The economic possibilities in the way of roadway strengthening by means of closer tie spacing, made possible by the use of the end tamper, deserve careful investigation.

2—No economically practicable way of materially increas-

*Conclusions of a paper by M. L. Byers, Mo. Pac. Ry., from the September Bulletin of the International Railway Congress.

ing speed on curves, without correspondingly increasing the super-elevation of the outer rail, is, so far, offered.

3—Economy of maintenance is probably frequently secured by the use of a stiffer track but, due to obscuring factors, the amount of economy secured is practically indeterminate.

4—(a) The use of one rail section, especially designed for straight track, and one or two rail sections, especially designed for curves, offers possibilities of economy in rail wear and should be further investigated. No compromise section of rail can be designed which will be economical under all conditions of curvature.

(b) The increase in the allowable per cent of carbon in rail steel, due to the reduction in the percentage of phosphorus, obtainable by the use of the basic open hearth process, results in a steel of such superior qualities as to point to the gradual abandoning of the acid Bessemer process as the high grade ores with low per cent of phosphorus become exhausted.

(c) Alloy steel offers such great possibilities of future usefulness that the development of the processes of manufacturing should be encouraged with a view to the ultimate reduction of the cost of the product.

(d) The design of the rail section so as to permit of the rolling of the head at low temperatures, is of the utmost importance.

(e) Slow pouring of the ingot and close attention to cropping, to eliminate impurities, is necessary in order to avoid the production of rails with dangerous defects.

5—The experimental use of steel and of reinforced concrete ties should be continued in view of the decreasing timber resources, but economic conditions are not yet ripe for the extended use of these substitutes for the wooden tie.

BRIDGES.

1—No definite rules for determination of the economic possibilities of bridge strengthening can be laid down, but each case must be specially considered on its merits.

2—The adoption of such methods of bridge design as will cause the different members of the structure to be uniformly stressed by the maximum permissible loading is desirable.

Grade Crossings

To eliminate the ten grade crossings over which all Pennsylvania Railroad trains running through Bristol, Pa., now pass, and to increase the safety of all travel, the railroad company today invited bids for the construction of an entirely new line through that city. The work will be started as soon as the contract is let, and will be completed in about a year.

The present line of the Pennsylvania Railroad through Bristol is on a heavy curve running through the center of the city. The proposed line will go straight through the western part of the city. This will eliminate the two curves of 1 deg. 20 min., and 1 deg. 40 min. The new line will be located about one-half mile west of the present station in Bristol. It will be 2¼ miles long, and will necessitate the building of about nine miles of track to prepare for a four-track railroad. The maximum curvature will be forty-five minutes. The total curvature will be 50 deg. 8 min., as against 101 deg. 22 min., in the present line.

Nine bridges will be built over streets and public roads, one bridge will be built over the Pennsylvania Canal and three over streams. To do this will require the grading of 550,000 cubic yards of earth, the building of 5,000 cubic yards of arch masonry, and 12,000 cubic yards of bridge masonry. All the bridges will be built of concrete and they will be reinforced over all streets to provide solid floors for tracks.

There are at present in Bristol ten grade crossings in

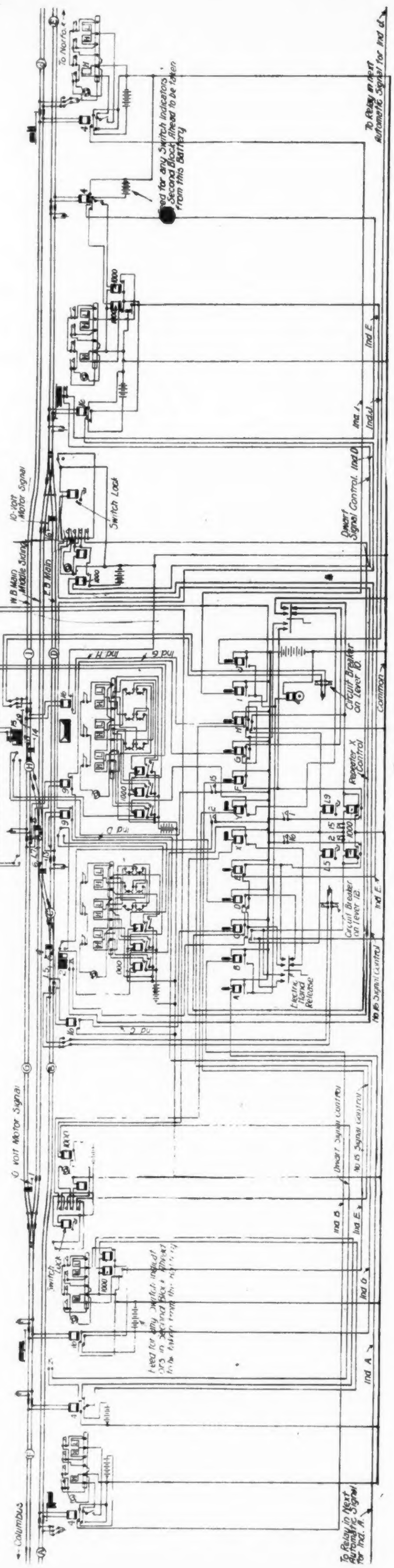


Fig. 3—Standard Circuits for Middle Sidings, N. & W. Ry.

the center of the city. These will be done away with on the main line. It is now thought that only two of the present four tracks will be left, and they will be kept in service as sidings to serve local industries in that section of Bristol. There will be no grade crossings on the new line.

The Pennsylvania Railroad has in the past ten years been eliminating grade crossings on its main line as rapidly as practicable, and in that time on the New York division alone 78 crossings at grade have been abolished. With the crossings to be eliminated by the new line through Bristol, there will have been removed since January 1, 1900, on the New York division a total of 88 grade crossings. The majority of the crossings remaining are over country roads in sparsely settled sections, where the travel is inconsiderable.

The Signaling Department

Standard Circuits for Automatic Block Signals

The circuits, shown in Figure 1, are used with the Union Style "B" mechanism in two arm, two position, lower quadrant signaling which is our standard on the Eastern General Division. The circuits shown in Figure 2 are used with the Union Style "S" mechanism in three position, upper quadrant signaling, which is our standard on the Western General Division. Figure 3 shows the standard circuits where there are middle sidings with interlocking plants in automatic signal territory.

All automatic signals and track circuits are operated by storage batteries charged from central stations located approximately twenty miles apart, each station charging the batteries ten miles in either direction. Duplicate sets of 40 ampere hour batteries are used for operation of signals and line circuits and duplicate sets of 120 ampere hour batteries for track circuits with proper switches in each signal for control of the circuits. Track circuits are provided with variable resistance units between battery and track to regulate the amount of current supplied.

Central stations for charging storage batteries are provided with one 12-H.P. gasoline engine, direct connected to a 7½ K.W. 600-volt shunt wound generator and a 6-H.P. gasoline engine direct connected to a 3½ K.W. 600-volt shunt wound generator and a switchboard so connected that either may be used to charge the batteries in either direction. The larger machine is used to charge the track batteries which require 15 amperes and the smaller to charge the signal batteries which require 5 amperes, either machine being used for both purposes in case of a break down of the other. Where electric power is available, two 5-H.P. 3 phase, 60 cycle, 220-volt induction motors are direct connected to 3½ K.W. 600-volt shunt wound generators, and these machines run in multiple to charge track batteries and singly to charge main batteries, either set being used for both purposes in case of a break down of the other.

All automatic signals are located approximately one mile apart, and where the alignment of the track requires a longer block than this, the track circuits are relayed. Polarized track circuits are used for the operation of the distant signals and switch indicators are placed at all switches other than short commercial sidings, etc. All relays used are the Union Switch & Signal Company's type 9-c. Where automatic signals extend through an interlocking plant, electric signals are used in place of the mechanical home signals and

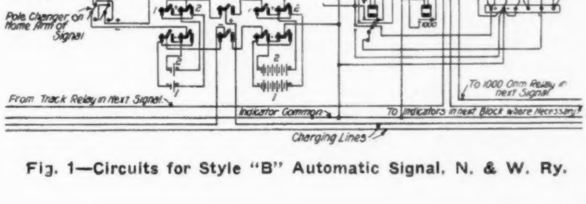


Fig. 1—Circuits for Style "B" Automatic Signal, N. & W. Ry.

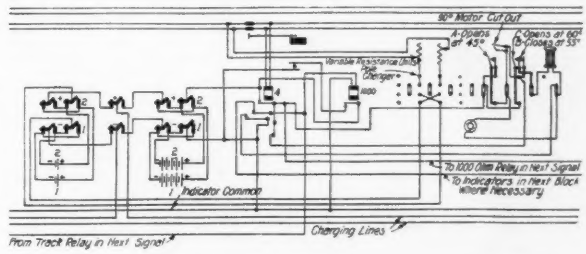


Fig. 2—Circuits for Style "S" Automatic Signal, N. & W. Ry.

are controlled by suitable circuit breakers on the mechanical levers. The tower indicators used are the iron case disappearing disc type.

All automatic signals now being installed are lighted by 2 cp. 10-volt tungsten lamps which take their current from the signal batteries and are so connected that they are lighted only when a train is in the block approaching the signals.

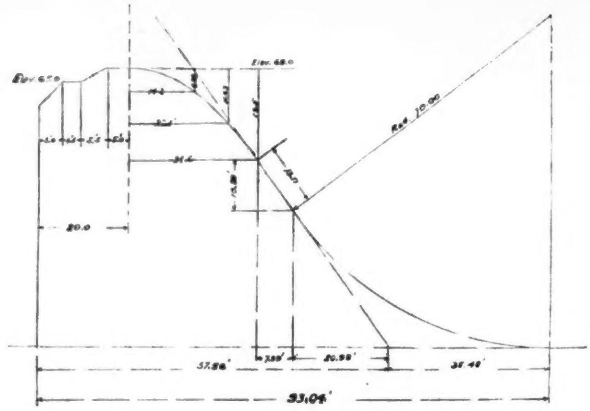
Gatun Spillway Dam

Plans Approved for the Concrete Structure.

A concrete dam in ogee form with crest on the arc of a circle in place has been decided upon for the barrier in the spillway of Gatun Dam. The proportions are such that the nappe will adhere to the masonry, and the curve at the tie will be sufficiently long to prevent any great disturbance being caused in turning the water back to the horizontal direction. By using the curved crest line the energy of the fall may be utilized to destroy to some extent the velocity of the water. Additional positive check will be provided in the form of masonry baffles, for otherwise it would be impossible to predetermine the point below which regular flow will be established.

In selecting a location for the spillway by which the height of water in Gatun Lake will be regulated, a hill about midway between the ends of the dam was chosen because in it the surface of the rock is about at sea level, and a good foundation was thus procured without excessive excavation. A channel 1,200 ft. long and 300 ft. wide has been excavated through the hill. This channel will be closed at its south or up-stream end by a concrete dam, with foundation at sea level at the toe and at 10 ft. above sea level at the upstream end. The dam will be 93.04 ft. long from heel to toe, 630 ft. long on the crest line across the channel, and the crest will be at 69 ft. above sea level. It will contain about 140,000 cubic yards of concrete. On top of the concrete dam will be built the regulating works, plans for which have not yet been approved.

After study of the maximum flow to be cared for and the probable rate of discharge over a dam of the section shown and with the heads that will obtain, it was determined that 14 gates, each 45 ft. wide, with still elevation at 69 ft. above sea level, will give absolute control of the lake under all possible conditions. The top of these gates when closed



Gatun Spillway Dam

will be at 87 ft. above sea level and the bottom when they are open will be 92 ft. Since little drift will have to be taken over the spillway dam, owing to the large size and irregular outline of the lake and the prevailing direction of the winds, the crest gates have been planned to open to elevation 92, which will give sufficient opening to allow any drift that may reach the dam to pass over. To prevent any large drift that may go over the dam from damaging them, it is proposed to face the baffles with heavy ribbed cast iron plates which will distribute the shock over the concrete.

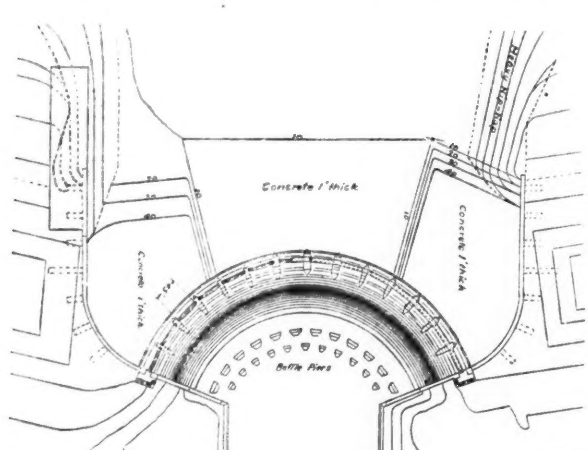
The cut through Spillway Hill has been paved and the sides are being lined with concrete, so as to give a smooth channel through which the Chagres River may discharge after the West Diversion is closed. Before the West Diversion is closed preparations will be made to build coffer dams, under shelter of which the concrete of the main spillway dam may be placed later.

It is considered necessary to have positive lake regulation during the construction of the spillway dam and of the locks, and in order to obtain this, and at the same time to test some of the Stoney culvert gates intended for the locks, three of the piers between the crest gates will be made much larger than the others. Culverts will be left through them at a low level and some of the gates already contracted for will be installed. In order at the same time to test one of the cylindrical valves for the lock, a fourth large pier will be constructed in which to install one of them. This valve will be set at a somewhat higher elevation than the Stoney gates and will, therefore, not assist in the regulation of the lake at low levels.

Preparations for installating the coffer dams have been made. The West Diversion will be closed and the flow of the river will then be through the channel and may be continued there as long as desired. During this time the end of the spillway dam, which will be founded upon the rock at elevation 40 ft. above sea level, may be constructed, as they will be well above the surface of the water flowing through the channel.

The lake should drain down to about 13 or 14 ft. above sea level during the dry season, and construction of the dam should, therefore, begin at that time of the year, when it is desired to fill the lake. The coffer dams may then be put in, shutting off the water and allowing the concrete to be placed. As soon as a few feet of concrete have been put in, the culvert gates should be opened and left wide open during the construction, except as they may be occasionally closed to permit the examination of the masonry inside the culverts. If they are left open in this way it will be possible to keep the construction of the dam ahead of the rise of the lake, so that there will be no danger of overtopping the new masonry. The dam should then be completed and the crest gates installed. It will be impossible to put in the machinery for five of these gates at the time they are installed, as the operating machinery for the three Stoney culvert gates and the one cylindrical gate will prevent it. There will, however, be sufficient available lake regulation with the nine crest gates, three Stoney culvert gates and the one cylindrical valve.

When it is desired to remove the Stoney gates and the cylindrical valve to the locks, the culverts will be closed by temporary gates at their upstream ends, thus shutting off the water and allowing the gates and valve to be removed. The culverts will then be filled with concrete. As soon as the gates and the valve have been removed the operating machinery for the remaining crest gates can be installed, completing the spillway.



Crest of Dam Showing 14 Gates in Regulating Works

Panama Railroad and High Water

The train leaving Colon at 5:15 on the morning of November 19 was the only one to get through, and the water was about 3 feet 2 inches over the rails between Tabernilla and Frijoles. The river rose rapidly all day Friday and attained its maximum stage by mid-afternoon at Mamei, and by 6 p. m. at Frijoles station. The water was 4 feet 8 inches over the rails at Frijoles station and 5 feet over the rails at mile post 18 at this time. It fell rapidly all day Saturday and Saturday night over the territory from Frijoles to Bohio, and on Sunday morning the tracks were entirely uncovered everywhere except at the Black Swamp and Bridge 27.

The Chagres had overflowed its banks at Ahorca Lagarto during the flood, and completely filled up the Black Swamp, and as the elevation of this swamp is very low, it was a slow process to drain this water into the Chagres River. On Sunday afternoon the first train passed over the line. Water stood 20 inches over the top of the rails at Black Swamp and Bridge 27. It drained away from Bridge 27 readily on the night of the 28th, which lowered the water in the Black Swamp about 6 inches, and some traffic was resumed. The rails in the Black Swamp have been out of water since November 27.

A second bridge is being built near Bridge 28 to provide more drainage for the Black Swamp in case of floods. The drainage channel is also being cleared out, so that water will drain off more quickly.

RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.
BRIDGES-BUILDINGS-CONTRACTING-SIGNALING-TRACK

Published by THE RAILWAY LIST COMPANY

WILLIAM E. MAGRAW, Pres. and Treas. WARREN EDWARDS, Manager
CHARLES S. MYERS, Vice-Pres. C. C. ZIMMERMAN, Adv. Mgr.
NORMAN F. REHM, Editor

Office of Publication: 315 Dearborn Street, Chicago
Telephone, Harrison 4948

Eastern Office: 50 Church Street, New York
Telephone, Cortlandt 5765

A Monthly Railway Journal

Devoted to the interests of railway engineering, maintenance of way, bridges and buildings.

Communications on any topic suitable to our columns are solicited.

Subscription price, $1.00 a year; to foreign countries, $1.50, free of postage. Single copies, 10 cents. Advertising rates given on application to the office, by mail or in person.

In remitting, make all checks payable to the Railway List Company.

Papers should reach subscribers by tenth of the month at the latest. Kindly notify us at once of any delay or failure to receive any issue and another copy will be very gladly sent.

Entered as Second-Class Matter April 13, 1905, at the Post Office at Chicago, Illinois, Under the Act of Congress of March 3, 1879.

Vol. V. Chicago, December, 1909 No. 12

Notification

With the close of this year we wish to thank our readers for the interest they have taken in RAILWAY ENGINEERING. To serve its purpose and be of use to those engaged in railway engineering and maintenance of way work, there must always be co-operation with our readers. It would not be possible to visit every one personally when they have information of interest to others, so we shall endeavor to keep in touch as heretofore.

To a great extent we want this paper to be both for railroad men and, in a way, by railroad men. We have come to this conclusion because of suggestions and encouragement received in this regard. While it was realized that many were too busy to write at length, yet they usually found it convenient to send a few notes.

With the January issue we will begin a series of articles on railway signaling that will be of interest to men in all departments, conveying such information as all engineering officials should have. The scope of this work will be outlined later, but it might be said at this time that the articles will be written by a railroad man who has had a thorough training in signaling work, and is therefore capable to do the subject justice. These articles will not go into the subject from the standpoint of a designer of signaling apparatus, because such information would not be of assistance, but rather from an operating standpoint.

Tie Plates

We would be pleased to receive any information at the disposal of our readers on the question of laying tie plates for publication in an early issue of RAILWAY ENGINEERING. We have been requested to publish available data on this subject, and believe that it will be of service to many.

We do not seek a discussion of the types of tie plates, but merely the method of laying those patterns with which you have had experience and the results of your methods. The assistance of any reader of the paper will be appreciated.

Rail Failures

A report on the subject, "Typical Rail Failures," by the Committee on Rail of the American Railway Engineering and Maintenance of Way Association, is contained in Bulletin No. 116. It covers statistics furnished by railroad companies throughout a period of six months.

All track men should have an interest in this work and obtain from the engineer in charge of the division the necessary report sheets. This reference is made to those who have not as yet given the matter attention.

Explanations should be requested in all cases of doubt as to classification of failures and in regard thereto we publish two paragraphs from the above-mentioned report:

"When the classification was originally proposed, it was the intention that all rails which broke in service, or which had a straight crack working from top to bottom, or from bottom to top, which would very quickly result in a broken rail, should be classified as 'broken rails,' regardless of internal defects. All of the other defective rails which were removed, not being 'broken' or damaged on account of wrecks, were to be classified under one of the other heads, from 3 to 7, both inclusive. It has developed, however, from the reports received by the committee, that sometimes a rail broken in service which has shown a cavity in the head has been called a 'split head' instead of a 'broken rail,' and that sometimes a rail with a crescent piece out of the base has been called a 'broken rail.' Doubtless these classifications are strictly true from one point of view, but they are not true from the point of view of the adopted classification, and that classification should be in force until changed by the association.

"The rail manufacturers have claimed that the heavy wheel loads might crush down the head by reason of overloading or over-stressing the metal and without the presence of any internal defect causing the failure, and classification No. 4, 'crushed head,' was made with the intention of ascertaining whether such was the fact or not. In these reports every case of crushed head, when the rail was cut open, shows that it was accompanied by an internal defect and it should have been classed as 'split head' rather than 'crushed head.' It was supposed that a crushed head might be considered the fault of the railroad company, while the 'split head,' full of seams and cavities, which we call 'pipes,' would be clearly the fault of the manufacturer. It seems advisable to the committee at present to continue the classification of 'crushed head' in order to ascertain if any examples can be found where good metal has been caused to fail by overloading and over-stressing."

The report contains 157 pages of data which have been partially classified to show the qualities of various steels. The effect of the proportionate amounts of constituent elements in the steels has not been shown graphically as yet, and the section of the rail in this connection has not been studied fully. As this work progresses evidence is being given that successful conclusions will be reached and the manufacturers will then be able to roll rails which will be less liable to breakage, besides being satisfactory as far as the present standard tests are concerned.

Cement Unloading Plant

System of Conveyors to be Installed on the Wharves at Cristobal

In order to facilitate the unloading of cement at the piers at Cristobal a contract has recently been let by the Panama Railroad Company to the Alvey-Ferguson Company, of Louisville, Ky., for a system of cement conveyors. The contract was signed on August 25, 1909, and delivery of the first complete conveyor unit, for cement in barrels, is to be made at New York within sixty days from that date, and two complete units for either barrels or bags are to be delivered at intervals of thirty days thereafter until all the units are delivered. Thirty days are allowed the contractor for the installation of each complete unit after the material reaches the Isthmus. There will be six conveyor units, two for cement in bags and four for cement in barrels, and each unit is to have a maximum capacity of 1,000 bags or barrels per hour. The price of the complete system of conveyors is $29,760, and the contractor agrees to furnish any additional units, that may be required within one year, at a specified price.

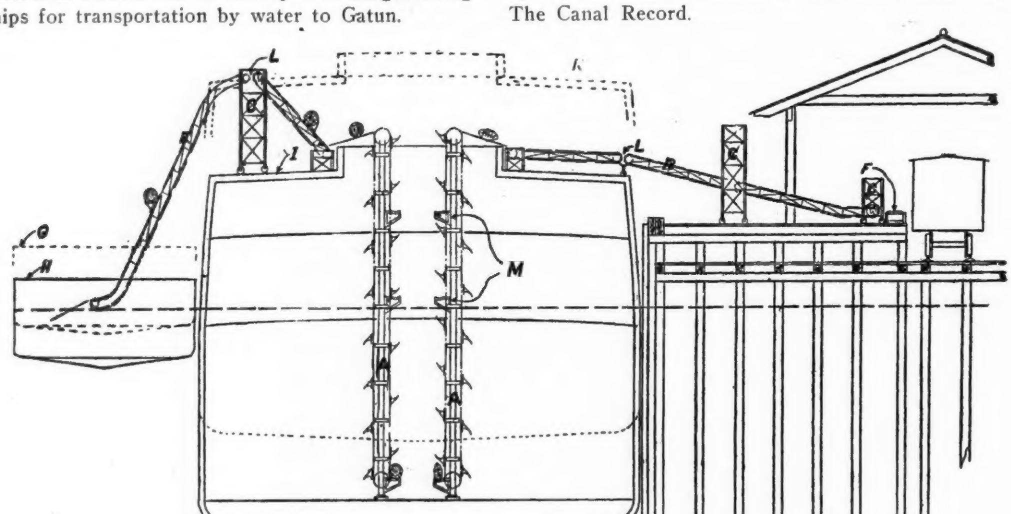
Over 4,000,000 barrels, or over 800,000 tons of cement, of the amount contracted for by the Isthmian Canal Commission in June, 1908, are yet to be brought to the Isthmus for use in the construction of the locks of the Canal, and for other purposes, most of which will be carried in the steamships Ancon and Cristobal. Each vessel makes one round trip a month between New York and Cristobal, and each has a maximum capacity of approximately 10,000 tons of cargo, usually about equally divided between cement and general freight. As the Ancon and Cristobal are twin ships, each vessel has the same arrangement of hatches, all of which have a clear opening of 17 ft. 4 ins. by 20 ft., except hatch No. 4, which has an opening of 19 ft. 6 ins. by 20 ft. It is the intention to have one unloading conveyor unit in each of six hatches and the vessel will be so loaded that the conveyor in the forward hatch, No. 1, can be used exclusively for cement in bags; those in hatches Nos. 2 and 3 for cement in barrels, that in No. 4 for bags, and those in Nos. 8 and 9 for barrels. The cement in bags will be conveyed to the pier for loading into freight cars for transportation by railroad to the locks at Pedro Miguel and Miraflores, or to any other point where it may be needed, and the cement in barrels will be conveyed to barges alongside the ships for transportation by water to Gatun.

The accompanying diagram shows the arrangement of a conveyor unit for bags and one for barrels. The unit for bags is composed of three parts: (1) a veritcal elevator for raising the bags of cement from the hold to the deck of the ship, consisting of a vertical shaft on which revolves an endless chain of brackets; (2) a portable apron conveyor at right angles to the ship, built in sections 20 ft. long, which conveys the bags from the deck of the ship to the pier, and which has two towers for adjusting the aprons as the vessel lightens and rises in being unloaded, there being a difference of 12 ft. betwen loaded and empty draughts; (3) a stationary apron conveyor, built lengthwise on the pier, which delivers the bags to any point along the railroad track.

The conveyor unit for barrels is composed of two parts: (1) a vertical elevator, the same as in the unit for bags; (2) a barrel lowerer, with an adjusting tower, which conveys the barrel of cement from the deck of the ship into the hold of the barge alongside. Hand labor will be required at three points only with the conveyor system, viz., in placing the bags, or barrels of cement in position on stationary brackets, located on each of the three decks of the hold, so that the brackets on the vertical elevator can raise them; on the pier, in transferring the bags from the stationary conveyor to the freight cars, and in the hold of the barge, in removing the barrels from the lowerer and stowing them away.

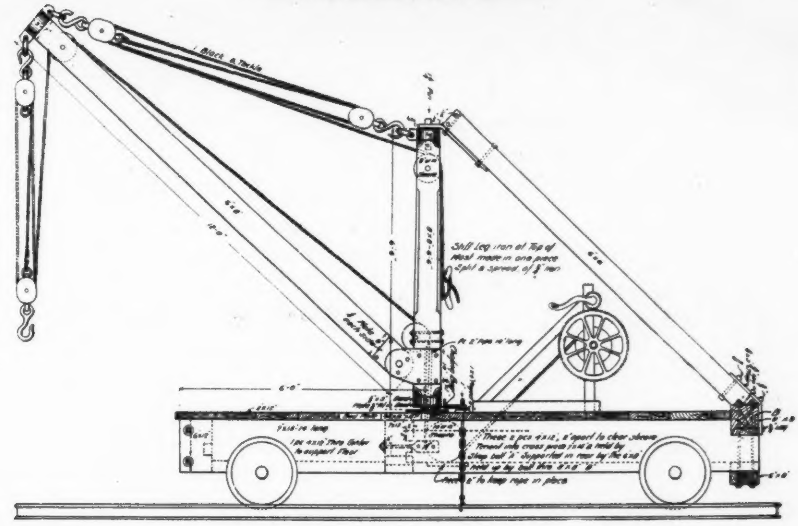
Each vertical elevator in the conveyor system will be operated by a 10-h. p. electric motor, each barrel lowerer by a 5-h. p. motor, each complete portable apron conveyor by a 3-h. p. motor, and each section of the stationary apron conveyor on the pier by a 7½-h. p. motor, making a total of 20½-h. p. for each bag conveyor unit, and 15-h. p. for each barrel conveyor unit. All motors will be totally enclosed and will be dust and moisture proof. Electricity for the motors will be supplied from the power house of the Gatun handling plant.

It is expected that one complete unit of the conveyor system will be in operation by December 1, and that at least two units a month will be completed and in operation thereafter until the entire system is installed. Any part of the conveyor system which may prove defective in workmanship, material, or design, within one year will be replaced by the contractor without cost to the railroad company.—The Canal Record.



Unloading—A, Vertical Elevator; B, Portable Apron Conveyor; C, Adjusting Tower; E, Barrel Lowerer; F, Stationary Apron Conveyor; G, Barge Empty; H, Barge Loaded; I, Ship Loade d; K, Ship Empty; L, Universal Joint and Coupling; Loading Stationary Brackets; N, Surface of Water

RAILWAY ENGINEERING AND MAINTENANCE OF WAY. BRIDGES–BUILDINGS–CONTRACTING–SIGNALING–TRACK



Yard Derrick for Handling Material, Mo. Pac. Ry.

Design of Portable Derrick and Push Car for Same*

Portable derricks, especially for use on push cars, are not in general use, yet some roads have reported using them with success for many years. This report will include all manner of small cars and derricks which have come to our attention, even such cars as may be used in yards for the handling of rails, frogs, timbers, etc., for both loading and unloading of material, and which are too large for service on the road, account of being too heavy to remove from the track.

On trestle work it is ordinarily the practice to put in all timbers by hand, making use of the push car only in taking the material to the bridge, yet it must be admitted that there are times and places where a small derrick car can be used to advantage, especially where the number of men is too small to handle the timber to advantage otherwise, and particularly on branch lines where traffic is not heavy, or on industry tracks, where there is a considerable amount of bridge work with little or no traffic, excepting switching. They are also claimed by some to be very useful in picking up material from under bridges where it is not convenient to have a large derrick or pile driver, with work train, on hand for the purpose.

H. E. Walker, Southern Indiana Ry.:

We use a very simple and crude affair on a push car with which to handle bridge timbers, and I find it to be a success. It consists of a simple horizontal frame, which swings on a pivot, on one end of which rests a common hand hoist. This outfit can be used to pick up quite large timbers from either side of the track. One man sits on the back end of the frame and handles the rope, while two men crank up the load. The gears may be taken from a hand car and the drum made from wood, concave in shape, as shown in the accompanying sketch. The hoist sits on the short arm of the frame and can be shifted about and is used only for lifting to the height of the car, having no derrick feature in connection with it.

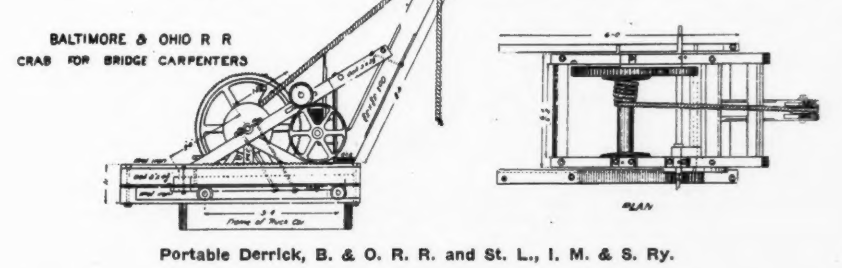
A. B. McVay, Louisville & Nashville R. R.:

I beg to advise that my knowledge of such appliances as portable derricks to be handled on push cars is very limited, my observation having been that such appliances for general bridge work are not very valuable; however, I now have in use on the St. Louis division a somewhat rude appliance of this kind which one of my foremen insists is very valuable and quite a labor saver.

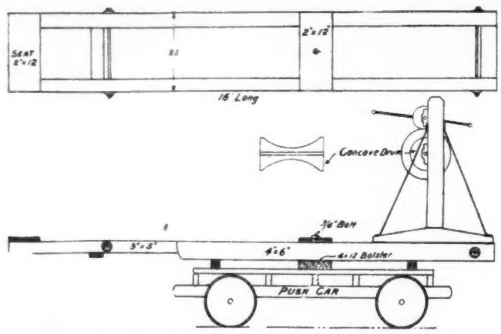
E. P. Hawkins, St. Louis, Iron Mountain & Southern Ry.:

We have a portable derrick which is made to use on a flat car, and to be shifted from one flat to another, the power to be furnished by line from locomotive or pile driver. Too heavy for push car work, yet I presume a similar lighter device could be made and furnished with a hand crab and used on a push car.

*From committee report of the American Railway Bridge and Building Association.



Portable Derrick, B. & O. R. R. and St. L., I. M. & S. Ry.



Windlass Hoist on Push Car, So. Ind. Ry.

We have a derrick and push car which is used in handling material in store yards, loading and unloading timber and other material around shops and storehouses, but too heavy for bridge work out on the line.

We also have a derrick designed by Mr. S. C. Tanner of the Baltimore & Ohio R. R., which is a good outfit for bridge carpenters and I think it would be well to recommend it to the Association. This is more in the nature of a hand hoist connected directly to a short boom derrick.

It is hoped by the committee that this meagre report will serve to animate a lively discussion, and that the discussion may prove to be of greater benefit to the Association than the report in itself.

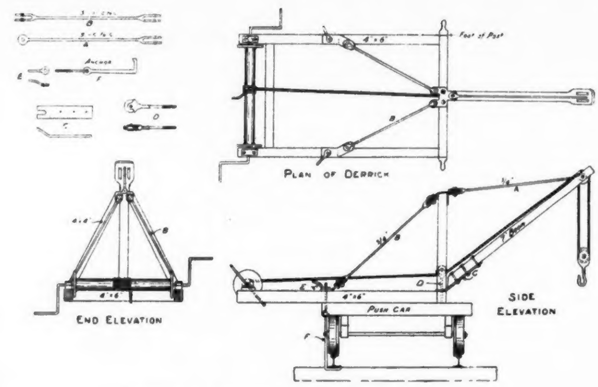
Lock Building at Panama*

The building of Gatun Locks was begun on August 24, when the handling and mixing plants were set in motion and the first concrete was laid. Only one of the three power units is in operation, and the capacity of this unit will not be reached until necessary adjustments are made in the automatic electric railroad, which carries materials from the storage to the concrete mixers. The concrete is being placed in the foundation of the center wall which will divide the two south, or upper locks.

Excavation was begun in October, 1906, and on July 31, 1909, there had been taken out 3,640,011 cu. yds. of material. There remained to be removed about 1,500,000 cu. yds., most of it in the middle and lower lock chambers. Work on the plant for mixing and handling concrete dates from September, 1908, when excavation for the power house was begun. The plant has a maximum capacity of 1,920 cu. yds. of concrete in eight hours.

There will be six locks in three pairs at Gatun, making the lift from sea level to 85 feet above sea level. Each lock will be 110 ft. wide, have a usable length of 1,000 ft., and there will be 41⅓ ft. of water over the sills when the surface of Gatun Lake is at the normal height of 85 ft. above mean sea level. The concrete construction includes the locks and approach walls, and it is estimated that in all about 2,096,000 cu. yds. will be laid.

The method of handling the materials for concrete and of conveying the concrete itself to the place where it is laid, involves three distinct operations. The first of these is the assembling of materials. It is estimated that 2,250,000 barrels of cement will be required for the concrete in Gatun Locks. The cement is shipped to New York from the manufacturer's plant in Northampton, Pa., after it has been tested by an agent of the government, and is brought to the Isthmus in ships owned by the government. From the docks in Colon or Cristobal it is carried in barges up the old French canal to the cement storage dock at Gatun. There it is unloaded by electric cranes and stored. Rock is quarried and crushed at Porto Bello, a village on the north coast of the Isthmus about 17 miles east of Colon, and is towed in barges to Cristobal, and thence up the French canal to Gatun. Sand is dredged at Nombre de Dios, also a north coast village about 35 miles east of Colon, and is towed in barges to Gatun. Two duplex and one single unloading cableway—five strands in cable in all—extend over the slip in which the barges tie up, and the rock and sand are picked up by clam-shell buckets and conveyed to a storage pile. An electric railway runs underneath the cement store house, under the rock and sand storage piles, and up to the battery of concrete mixers. Cars pass along this railway and are charged in succession with cement, sand and rock, in proportions of 1, 3, and 6, thus completing the operation of assembling the materials.



Push Car Derrick, St. L., I. M. & S. Ry.

In the second operation, that of mixing the concrete, the loaded cars run up an incline to a platform over the mixers where the material is dumped. There are eight mixers, so mounted that they dump by gravity into tip buckets. These buckets are carried on cars that run on a railway track along the west bank of the lock site.

After the concrete is dumped onto a car, an electric locomotive, fed by the third rail system, takes it to any point along the lock site. The full buckets are lifted from the cars by cableways that stretch across the lock site, and are lowered into the chamber at the spot where it is desired to lay the concrete. Each locomotive hauls out a train of two cars, each car carrying one loaded bucket. An empty bucket is placed on each car by each strand of the duplex cableway, and the loaded buckets are then hoisted. The empty buckets are then hauled back to the mixers for another load. Twelve locomotives and 24 cars are in use when the plant is running at full capacity. The buckets are nicely balanced and can be tipped with slight effort. Power for all the operations is supplied from an electric power plant. Delivering the concrete and placing it from the third operation.

DETAILS OF THE PLANT.

Additional details about the plant follow:

Unloading Cableways.—These cableways are of the same construction as those over the locks, details of which are given below. They operate with self-digging automatic grab buckets of the two blade type, 70 cu. ft. capacity, and convey rock and sand from barges to the storage piles. There are five strands of cable in all, two duplex and one single. The maximum carry is 675 ft.

Cement Dock and Storage Piles.—The cement dock has a frontage of 490 ft. along a slip that leads from the old French canal, and is 110 ft. wide. Cement is unloaded from barges by ten traveling cranes of the three-motor type. One hundred thousand barrels of cement, more than a month's supply, can be stored here. Over the tracks on which the

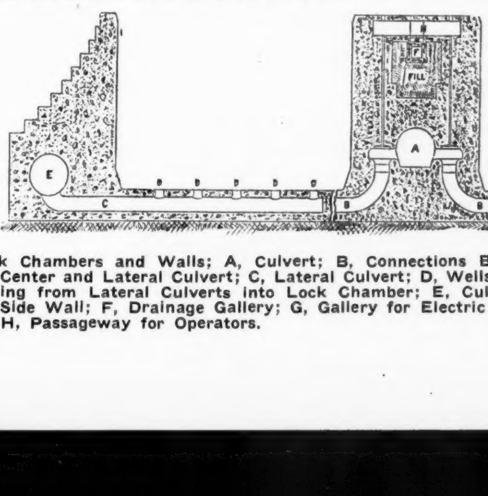
*See Fig. 6, page 264, article on cableways at Gatun locks.

material cars run are 30 hoppers for cement, each hopper with a valve 15 by 30 ins. The cement is dumped into the hoppers and the valves regulate the charging. The material cars run beneath the sand and rock storage piles in two tunnels, and the cars are charged with sand and rock in the same way as with cement. There are 22 valves, each 15 ins. square under the sand pile, and 46 valves 15 by 30 ins. under the rock pile.

Railroad from Storage Piles to Mixers.—Two railroads of 24-in. gauge lead from the cement dock and storage piles to the concrete mixers, the total length of each road being about 4,700 ft. The railroads are entirely separate from one another, as the object of their being in duplicate is that one may be in service while the other is undergoing repairs. The cars in which the materials are carried are individually driven by three-phase motors chain geared to the axles, taking an alternating 25-cycle current of 220 volts from two inverted collecting rails laid between the traction rails. Each car is started, stopped, or reversed by the operation of a master switch, so located that it can be controlled from either side. When this switch is thrown the car starts and automatically comes up to speed, and whether traveling on the level or on the heaviest grade on the mixer plant incline the speed never varies more than ten per cent. When the empty cars descend the grade from the mixers to the storage piles their motors are reversed into generators and power is returned to the line. Automatic magnetic brakes stop the cars in case of accident and thus anticipates collisions. The cars are built of steel, are divided into two compartments, one for sand and concrete, and one for rock, and have a capacity of 80 cu. ft. They are of the hinged, side door type and when over the hoppers of the mixers their doors are opened by hand. Forty-two of these cars are ready for service.

Mixing Plant.—Eight improved Chicago cube mixers of 64 cu. ft. capacity each, belt driven from shafts capable of making 180 revolutions a minute, with 14 revolutions a minute for the cube, compose the mixing plant. These mixers are erected above the level of the cars into whcih they discharge. They are charged by gravity, that is, the material cars run up an incline to a platform over the mixers where they dump into charging hoppers of 90 cu. ft. capacity, so designed as to throw the materials into the mixers. The mixers receive and discharge their load without stopping or slowing down, and one operator controls the charging and discharging. The mixers are mounted in one file eight deep, and four of them discharge over a railroad on the east side, and four over a road on the west of the mixing plant.

Concrete Carrying Railroad.—A railroad of four tracks runs along the west bank of the locks, two tracks on either side of the mixer plant. A train, consisting of a locomotive and two flat cars, each car carrying one bucket, stops alongside two of the mixers and receives concrete from them. It then runs to the point on the bank where the cableway is waiting, and the cableway deposits two empty buckets and picks up the loaded ones. The train then backs up on the return track and waits its turn to switch alongside the mixers. There are 12 locomotives and 24 flat cars in this service. The locomotives are 12 ft. long, 6½ ft. wide and 5½ ft. high above the deck. They have single trucks with rigid wheel base, and a required draw-bar pull of 2,000 lbs. They are propelled by two reversible, waterproof, railway motors, one on each axle, taking current from a third rail. The cars are built entirely of steel, and are 18 ft. long and 7 ft. wide, with the deck 2 ft. 8 ins. above the rails, and are mounted on double trucks of eight wheels with a four-foot base. Each car has a receptacle for two buckets, and will carry a load of 12 tons.



Lock Chambers and Walls; A, Culvert; B, Connections Between Center and Lateral Culvert; C, Lateral Culvert; D, Wells Opening from Lateral Culverts into Lock Chamber; E, Culvert in Side Wall; F, Drainage Gallery; G, Gallery for Electric Wires; H, Passageway for Operators.

Cableways Over the Lock Site.—There are eight of these cableways arranged in pairs, each pair stretching from a steel tower on the west bank of the locks to a similar tower on the east bank, a distance of 800 ft. The towers are 85 ft. high above the tracks on which they move along the banks above the lock site. Each of the tail towers on the east bank moves synchronously with the tower opposite it on the west bank, and the movement of each pair is controlled from the control station in the head tower on the west bank. The carrying cable is a locked steel wire 2¼ ins. in diameter, and on this cable a traveler is pulled back and forth over the lock chamber. On the traveler is a pulley through which runs a cable to lift material and drop it. The maximum distance the traveler is required to run is 670 ft., the greatest lift 170 ft., and the carrying capacity is not less than six tons, with 20 trips an hour. In all these respects the cableways exceed the requirements. The machinery for operating is mounted in the head towers on the west bank of the lock site. It consists of a motor of 150-h. p. to turn the hoisting and conveying cable drums, a motor of 25 h. p. to run the dumping device, and a motor of 25 h. p. in both head and tail towers to propel the towers. One man operates a cableway, controlling all the movements by switches located on a platform on each head tower. In addition to delivering concrete in the locks the cableways will be used to lift material from the lock site and dump it by an aerial dumping device, to handle forms for the concrete work, and to handle the part of the gates and the gate operating machinery.

Power Plant.—Power is supplied by an electric generating plant, a detailed description of which was given in The Canal Record of April 28, 1909. Six water tube boilers of the Keeler type, each with a nominal rating of 400 h. p. and generationg steam at 205 lbs. absolute pressure and 150 degs. Fahrenheit of superheat, supply steam to three Curtis, 1,500-kw., vertical steam turbine base condenser generators. The plant is modern in all respects. After the canal is completed this plant will be used as an auxiliary to the hydraulic power plant for operating the locks.

LAYING THE CONCRETE.

The concrete laying for months to come will be confined to the upper locks. Excavation for the curtain walls is carried on by rock channelers and orange peel dredges, and is almost completed. Floor anchors have been placed in about a half of the east lock and the excavation in the chambers of the upper locks is practically done. The plan to be followed in laying the floor was discussed at length in the report published in The Canal Record of July 14, 1909. The summary of the report is as follows:

That the floor of all that part of the chamber lying below the sill of the upper pair of upper lock gates should be treated as belonging to the lock, and the portion above that sill as belonging to the forebay.

That the floor and walls of the forebay from the sill of the movable dam to the sill of the upper duplicate lock gates should be founded at reference plus 4, and that the floor there should be made 20 ft. thick.

That from the upper surface of the sill of the upper duplicate lock gates to and including the sill of the intermediate

gates, the excavation for the floor and walls should be carried to plus 0.67.

That this part of the floor should be made of uniform thickness of 13 ft., and should be anchored down by rails spaced as nearly as practicable 6 ft. apart, longitudinally and transversely.

That the rails should be anchored by concrete to a least depth of 10 ft. in the underlying material in the outer parts of each lock pit, and in the middle part the penetration should be from 15 to 20 ft., depending upon the material.

That below the intermediate gate walls the foundations for the walls and floors should be trenched for the culverts, the floor between the culvert trenches being made three feet thick, and all floors anchored to the underlying material with rails penetrating not more than 10 ft.

That a curtain wall 6 ft. thick should be constructed along the sill of the emergency dam and the upper portion of the lock walls; the wall along the sill to be carried to reliable material, the least depth of the foundation to be minus 8, the walls along the lock walls to be founded at the depth of the foundation of the corresponding end of the cross curtrain wall until the soft sandstone stratum is met, and thence at a depth of one or two feet below the surface dividing the soft sandstone and the argillaceous sandstone with tufa until the depth of minus 18 is reached.

FORMS FOR THE CONCRETE.

The concrete in the walls and floors must be laid with reference to the culverts which will be embedded in it for the purpose of carrying water in filling and emptying the lock chambers. There will be three main culverts extending the full length of the locks, one in each of the side walls and one in the middle wall. The side wall culverts will be 22 ft. in diameter from the intake at the south end of the south, or upper locks, to a point 320 ft. north, where they will be reduced to 18 ft., at which diameter they will continue to the end, a distance of about 3,500 ft. The bottoms of these culverts will be 2½ ft. below the surface of the floor. The culvert in the middle wall will be 22 ft. in diameter from its south end to a point 120 ft. north where it also will be reduced to 18 ft., at which diameter it will continue to the end, a distance of about 3,600 ft. The bottom of this culvert will be in general 10½ ft. above the surface of the lock floors.

Lateral culverts, in the form of an eclipse 6½ ft. high and 8 ft. wide will run in the floor from and at right angles to the main culverts at intervals of 32 and 36 ft., leading alternately from the side and middle culverts. The top of each lateral culvert will be 3 ft. below the surface of the floor. Water will be delivered or collected by each lateral culvert through five openings or wells in the floor. Valves, which may be opened or closed either individually or all at one time, will be located at the intakes and outlets of the main culverts, and at the connections between the center culverts and the lateral culverts.

Forms for the culverts are made of open hearth boiler steel, are collapsible, are mounted on wheels to facilitate withdrawal, and are constructed to stand five years of continual use. For the main culverts in the side walls there are 21 forms in 12-ft. lengths, each form weighing not less than 303,300 lbs. There are 12 forms for the culvert in the middle wall, each 12 ft. long, and weighing not less than 177,000 lbs. There are 100 forms for the lateral culverts, each 10 ft. long, and weighing not less than 217,000 lbs. All the culvert forms are being constructed by the Baltimore Bridge Company, and delivery will begin in a few weeks.

Forms for the valve recesses and openings in the floors were made at Gorgona foundry. There are eight sets of valve recess forms, made of boiler plate, and weighing 21,400 lbs. each. The forms for the floor wells are made of cast iron and boiler plate, and weigh 61,000 lbs. each. There are forty of these forms.

The floor and walls will be built up in monoliths. Forms for the floor are made of timber and are 50 ft. long, 20 ft. wide, and their height will vary with the thickness of the floor, which will be 20 ft. in the south forebay and 13 ft. in the south locks. These forms are built in the lock site and will be moved from place to place by the cableways.

The side walls will be 50 ft. wide at the surface of the floor, will be perpendicular on the face, and will narrow from a point 24⅓ ft. above the floor until they are 8 ft. wide at the top. The narrowing will be accomplished by a series of steps each 6 ft. high. The middle wall will be 60 ft. wide, approximately 81 ft. high, and each face will be perpendicular to the floor. At a point 42⅓ ft. above the surface of the floor and 15 ft. above the top of the middle culvert, this wall will be diminished by a series of five steps, 6 ft. high center much like the letter "U," which will be 19 ft. wide at the bottom. From this point the two parts of the center wall will be diminished b ya series of five steps, 6 ft. high and 4, 3, 2, 2, and 1½ ft. wide, to a coping 8 ft. wide at the top. In this center space, which will thus be 19 ft. wide at the bottom and 44 ft. wide at the top, will be a tunnel divided into three stories or galleries. The lowest gallery will be for drainage; the middle, for the wires that will carry the electric current to operate the gate and valve machinery, which will be installed in the center wall, and the top, a passageway for the operators.

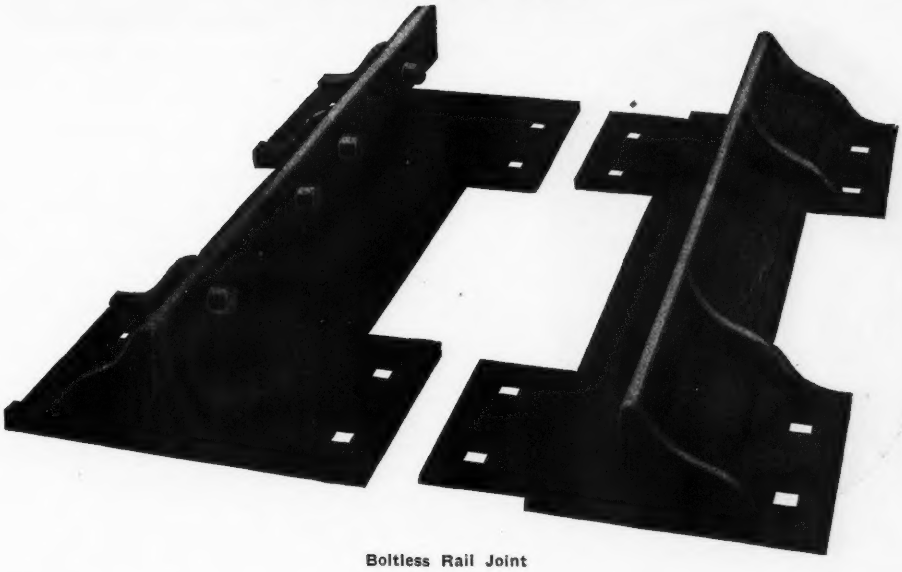
Face forms for the side and center walls are of sheet steel carried on movable towers, also built of steel. Tracks will be laid as near to the line of the walls as possible, and on these tracks the towers will move up and down the lock chambers parallel with the walls. Jacks fixed to the towers and bearing on the forms will be used to align the forms and hold them in place. There will be twelve of these towers with forms 78 ft. long from top to bottom, 36 ft. wide, and 7½ ins. thick. Tower and form will weigh at least 4,392,220 lbs. For the sides or ends of the wall monoliths, steel girders 6 ft. high will be built up in succession to the full height of the wall before the placing of concrete is begun. For the backs of the walls steel girders with triangular bracing will be used. The forms and towers for the side and middle walls are being made by the United States Steel Products Company.

Cast Steel Tie Plates and Rail Joints

A number of interesting articles of track equipment, made of cast steel, are being manufactured by the Pittsburg Track Specialty Co., House building, Pittsburg, Pa. These include ties, rail joints, tie plates and cast steel poles and posts.

The cast steel tie plate, shown in the accompanying illustration, is now in actual service, and, it is claimed, has demonstrated that it will hold rails in position under the most trying conditions. It is interlocking, and when spiked in position clamps a rail permanently. It is to be used in connection with a wooden tie.

The cast steel rail joint is a development of the tie plate. It has been in service in both the insulated and non-insulated patterns on the Pittsburg & Lake Erie, near Glassport, Pa., and is claimed to have given good satisfaction. It can be modified to suit any condition and can be trussed in the middle of the joint if desired. It is stated that one of these insulated joints has been in service on a particularly trying joint since last February, and has not been changed since placed in position. Previously the average life of insulation at this point was two weeks. The cast



Boltless Rail Joint

steel rail joint is shown in the illustrations as a boltless joint, but it can be made for use with bolts if desired.

It is only within the last few years that the art of making steel castings has been so perfected that a first-class cast steel rail joint could be made at prices that could be compared with the cost of the rolled joints. It is, however, now

Tie Plate in Position

possible to make in cast steel the rail joints described here and sell them in competition with the rolled joints. The company is making a proposition to railroads to equip a mile of track which is to be paid for only after, in actual service, it has been proved that this mile of road will be held in alignment, will protect the rail ends better, and will cost less for maintenance than any other mile on the road.

The company is also prepared to engage in the manufacture of cast steel poles for special purposes and is filling an order for 74 30-ft. cast steel trolley poles for the Butte Electric & Power Co., Butte, Mont. This is possibly the first installation of cast steel poles in the United States, and it is attracting the attention of the management of a number of the electric railway systems in the country. The cast steel pole is made considerably thicker at the ground line, where all poles suffer most deterioration and where the strain is greatest.

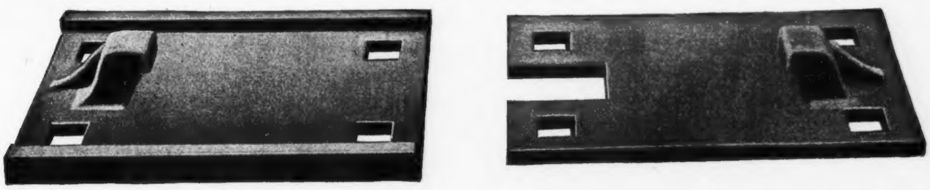
Personals

Mr. Louis C. Fritch, consulting engineer of the Illinois Central and its electrification expert, has been appointed chief engineer of the Chicago Great Western, effective November 15. Mr. Fritch has been connected with the Illinois Central for several years and formerly was assistant to President Harahan. He was made consulting engineer last February soon after the road announced its intention to investigate the feasibility of electrifying its Chicago terminals. Mr. Fritch is vice-president of the American Railway Engineering and Maintenance of Way Association and chairman of its committee on electrification.

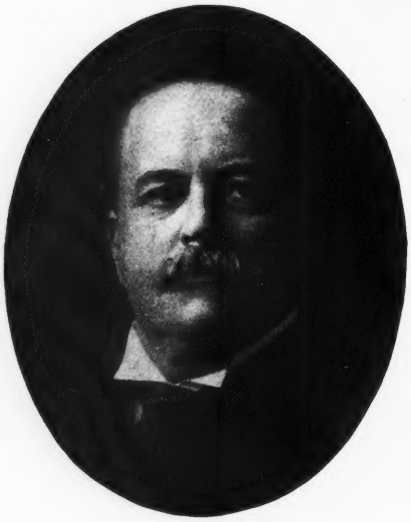
Mr. A. B. Warner, assistant chief engineer of the Chicago, Rock Island & Gulf, has been appointed chief engineer, with office at Fort Worth, Tex., succeeding Mr. C. M. Case, resigned.

Mr. J. W. Pfau, engineer of grade crossing elimination of the New York Central & Hudson River at New York, has been appointed engineer of construction, succeeding Mr. F. B. Freeman, who has become chief engineer of the Boston & Albany.

Mr. T. W. Fatherson has been appointed a district engineer of the Choctaw district of the Chicago, Rock Island & Pacific with office at Little Rock, Ark., succeeding Mr. H. G. Clark, assigned to other duties.



Interlocking Tie Plate



Julius Kruttschnitt

Mr. George O. Lundy has been appointed a supervisor of the Philadelphia & Reading, with jurisdiction over the Reading, Columbia, Schuylkill and Lehigh divisions, with office at Reading, Pa., succeeding Mr. William Zeller, retired.

Mr. John Reddy, roadmaster of the Southern Pacific lines east of Sparks, at Wells, Nev., has been transferred from the Wells district, and will have his office at Ogden, Utah, succeeding J. A. Allen, deceased. Mr. A. E. Moquist, roadmaster at Mina, Nev., succeeds Mr. Reddy and Frank Reilly succeeds Mr. Moquist.

Mr. C. A. Morse, chief engineer of the lines of the Atchison, Topeka & Santa Fe east of Albuquerque, N. Mex., at Topeka, Kan., has been appointed chief engineer in charge of maintenance and improvement of the Atchison, Topeka & Santa Fe system, succeeding Mr. W. B. Storey, Jr., recently elected vice-president. Mr. Morse will retain his office at Topeka for the present.

Mr. H. M. Levinson has been appointed a roadmaster of the International & Great Northern, with office at San Antonio, Tex.

Mr. F. J. Allen has been appointed resident engineer of the Missouri & North Arkansas, with office at Eureka Springs, Ark. Mr. H. R. Irvine has been appointed general roadmaster, with office at Searcy, Ark.

Mr. C. R. Breck has been appointed chief locating engineer of the Southern Pacific in the state of Jalisco, succeeding Mr. R. E. Hardaway.

Mr. P. H. Dudley, C. E., Ph. D., has been appointed a consulting engineer of the New York Central lines on rail, ties and structural steel, with office at the Grand Central station, New York.

Mr. E. E. Kurtz has been appointed an assistant district engineer of the New York Central & Hudson River, with office at Corning, N. Y., in charge of the territory covered by the Pennsylvania division.

Mr. D. D. Colbin, district engineer of the National Railways of Mexico at Guadalajara, Mex., has been appointed chief engineer of the Pan-American, with office at Gamboa. Mr. Eduardo Sabathe succeeds Mr. Colbin.

The jurisdiction of Mr. James M. Reid, chief engineer of the National Railways of Mexico at Mexico City, which has heretofore been confined to location and construction, has been extended over the department of maintenance of way.

Mr. Jacob Haas, roadmaster of the Atchison, Topeka & Santa Fe at Dodge City, Kan., has been appointed roadmaster, with office at Hutchinson, Kan. He will have jurisdiction over part of the territory previously in charge of Mr. A. West. Mr. Edward Marshall succeeds Mr. Haas.

Julius Kruttschnitt

Julius Kruttschnitt, director of maintenance and operation of the Harriman Lines, and vice-president of the Southern Pacific, and J. C. Stubbs, traffic director of the Harriman Lines and vice-president of the Southern Pacific, have each been elected vice-president also of the Union Pacific. The elections of Messrs. Kruttschnitt and Stubbs as vice-presidents of the Union Pacific are, in a way, only a matter of form, as they had charge before of the maintenance and operation and the traffic departments, respectively, of the Union Pacific as well as of all the other Harriman lines. The additional titles which they have been given are mainly in the nature of compliments to them and will, perhaps, enable them to exercise certain powers which they technically could not have exercised before. The positions which they occupy in the railway world are so well known and are so pre-eminent that it may be almost superfluous to refer to them. Mr. Harriman chose them from among all of the operating and traffic officers of his railway system to be his chief aids in the direct management of the properties. Under him they really performed in their respective departments duties which on most railways are performed by the president. Perhaps the reasons which caused Mr. Harriman to create the offices they hold and to appoint them to those offices were never so well stated as by Mr. Kruttschnitt in the paper on the operating organization of the Union Pacific and Southern Pacific systems, which he read before the New York Railroad Club last May. Mr. Kruttschnitt said: "Mr. Harriman is a firm believer in team work, and in turning over the management of the properties to his two coordinate representatives in Chicago, with the injunction that on them rested the responsibility for net results, he struck the keynote of the entire organization. From the Chicago offices down to the divisions the traffic officers co-operate as loyally to secure low operating results as the operating officers do to promote business and secure new traffic." Speaking of the duties of his own office, Mr. Kruttschnitt said it "standardizes and correlates, supervises and investigates, comments and criticizes, equalizes and differentiates as among different properties, but leaves each to work out its own problems of administration." This description of the duties of the office of the director of maintenance and operation applies equally well to the duties of the office of traffic director. The wonderful prosperity of the Harriman lines in recent years has been due in very large measure to the way in which the offices of Mr. Kruttschnitt and Mr. Stubbs have been administered, and no man would undertake to say which of these two eminent railway experts has contributed the more to securing those results. Each has contributed his share toward making the net earnings of the system as a whole one of the wonders of the railway world.

Mr. Kruttschnitt was born July 30, 1854, at New Orleans, La. He graduated as a civil engineer from Washington and Lee University in 1873, and for some years after graduation was a teacher in a school for boys near Baltimore, Md. He began railway work in 1878 as an engineer with Morgan's Louisiana & Texas Railroad & Steamship Company. On January 1, 1880, he was made roadmaster of the western division, and in the following year became assistant chief engineer and general roadmaster. He was appointed chief engineer and superintendent in April, 1883. He became assistant manager of the Atlantic system of the Southern Pacific in October, 1885, and was made general manager of that system as well as vice-president of the Galveston, Harrisburg & San Antonio, and of the Texas & New Orleans in July, 1889, which positions he held for six years. He was then, until April, 1904, general manager of all lines of the Southern Pacific Company, having been made vice-president in April, 1898. In April, 1904, he was made director of maintenance and operation of the Harriman system.

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